December, 1973 Price, $1.50

Technology Review

Edited at the Massachusetts Institute of Technology

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1974 marks the tenth year of operation for this unique program of tours, which visits some of the world's most fascinating areas and which is offered only to alumni of Harvard, Yale, Princeton, M.I.T., Cornell, Univ. of Pennsylvania, Columbia, Dartmouth, and certain other distinguished universities and to members of their families. The tours are designed to take advantage of special reduced fares offered by leading scheduled airlines, fares which are usually available only to groups or in conjunction with a qualified tour and which offer savings of as much as $500 over normal air fares. In addition, special rates have been obtained from hotels and sightseeing companies.

The tour program is consciously designed for persons who normally prefer to travel independently and covers areas where such persons will find it advantageous to travel with a group. The itineraries have been carefully constructed to combine as much as possible the freedom of individual travel with the convenience and savings of group travel. There is an avoidance of regimentation and an emphasis on leisure time, while a comprehensive program of sightseeing ensures a visit to all major points of interest.

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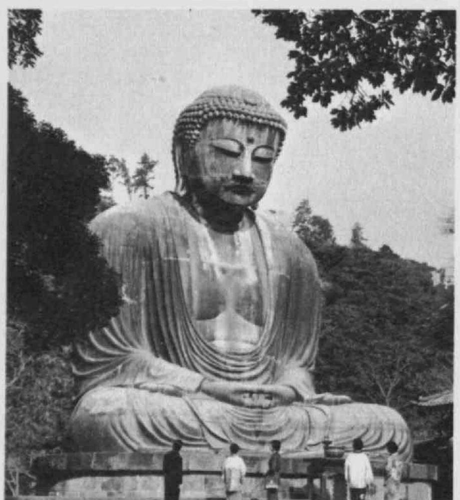
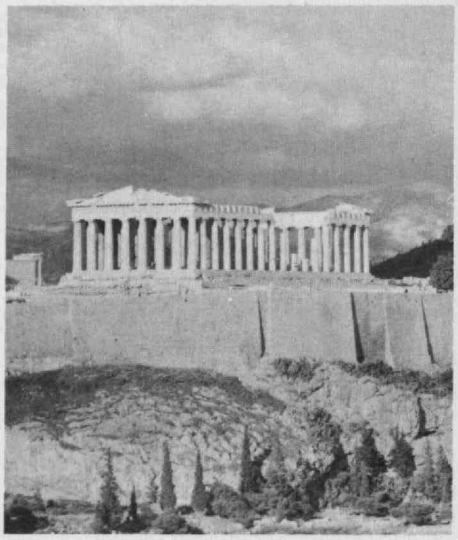


THE ORIENT

29 DAYS $2050

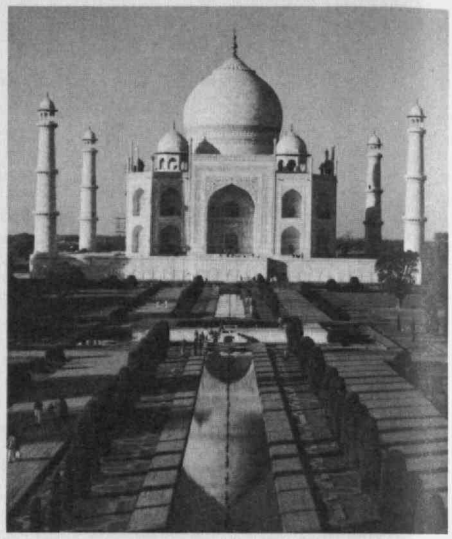
A magnificent tour which unfolds the splendor and fascination of the Far East at a comfortable and realistic pace. Eleven days are devoted to the beauty of JAPAN, visiting the modern capital of TOKYO and the lovely FUJI-HAKONE NATIONAL PARK and placing special emphasis on the great "classical" city of KYOTO (where the splendor of ancient Japan has been carefully preserved), together with excursions to historic NARA, the great medieval shrine at NIKKO, and the giant Daibutsu at KAMAKURA. Also included are BANGKOK, with its glittering temples and palaces; the thriving metropolis of SINGAPORE, known as the "cross-roads of the East"; the glittering beauty of HONG KONG, with its stunning harbor and famous free-port shopping; and as a special highlight, the fabled island of BALI. Optional visits are also available to the ancient temples of ancient Java at JOGJAKARTA and to the art treasures of the Palace Museum at TAIPEI, on the island of Taiwan. Tour dates include special seasonal attractions such as the spring cherry blossoms and magnificent autumn foliage in Japan and some of the greatest yearly festivals in the Far East. Total cost is $2050 from California, with special rates from other points. Departures in March, April, May, June, July, September, October and November, 1974 (extra air fare for departures July through October).



AEGEAN ADVENTURE

22 DAYS $1575

This original itinerary explores in depth the magnificent scenic, cultural and historic attractions of Greece, the Aegean, and Asia Minor—not only the major cities but also the less accessible sites of ancient cities which have figured so prominently in the history of western civilization, complemented by a cruise to the beautiful islands of the Aegean Sea. Rarely has such an exciting collection of names and places been assembled in a single itinerary—the classical city of ATHENS; the Byzantine and Ottoman splendor of ISTANBUL; the site of the oracle at DELPHI; the sanctuary and stadium at OLYMPIA, where the Olympic Games were first begun; the palace of Agamemnon at MYCENAE; the ruins of ancient TROY; the citadel of PERGAMUM; the marble city of EPHESUS; the ruins of SARDIS in Lydia, where the royal mint of the wealthy Croesus has recently been unearthed; as well as CORINTH, EPIDAUROS, IZMIR (Smyrna) the BOSPORUS and DARDANELLES. The cruise through the beautiful waters of the Aegean will visit such famous islands as CRETE with the Palace of Knossos; RHODES, noted for its great Crusader castles; the windmills of picturesque MYKONOS; and the charming islands of HYDRA and SANTORINI. Total cost is $1575 from New York. Departures in April, May, July, August, September and October 1974 (extra air fare for departures in July and August).



MOGHUL ADVENTURE

29 DAYS $1950

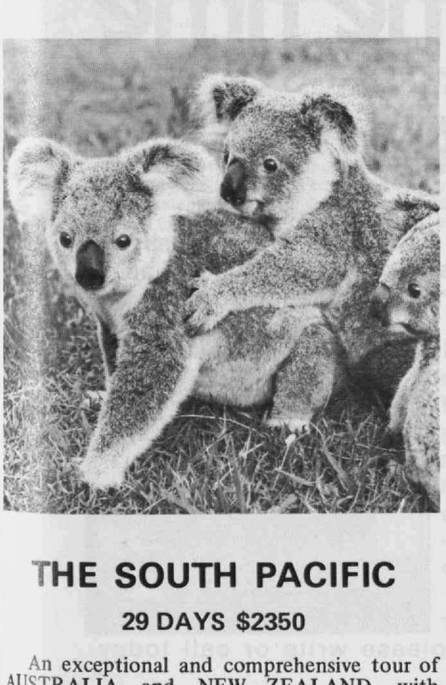
An unusual opportunity to view the outstanding attractions of India and the splendors of ancient Persia, together with the once-forbidden mountain-kingdom of Nepal. Here is truly an exciting adventure: India's ancient monuments in DELHI; the fabled beauty of KASHMIR amid the snow-clad Himalayas; the holy city of BANARAS on the sacred River Ganges; the exotic temples of KHAJURAHO; renowned AGRA, with the Taj Mahal and other celebrated monuments of the Moghul period such as the Agra Fort and the fabulous deserted city of Fatehpur Sikri; the walled "pink city" of JAIPUR, with an elephant ride at the Amber Fort; the unique and beautiful "lake city" of UDAIPUR; and a thrilling flight into the Himalayas to KATHMANDU, capital of NEPAL, where ancient palaces and temples abound in a land still relatively untouched by modern civilization. In PERSIA (Iran), the visit will include the great 5th century B.C. capital of Darius and Xerxes at PERSEPOLIS; the fabled Persian Renaissance city of ISFAHAN, with its palaces, gardens, bazaar and famous tiled mosques; and the modern capital of TEHERAN. Outstanding accommodations include hotels that once were palaces of Maharajas. Total cost is $1950 from New York. Departures in January, February, March, August, September, October and November 1974.

SOUTH AMERICA

32 DAYS $2100

From the towering peaks of the Andes to the vast interior reaches of the Amazon jungle, this tour travels more than ten thousand miles to explore the immense and fascinating continent of South America: a brilliant collection of pre-Colombian gold and a vast underground cathedral carved out of a centuries-old salt mine in BOGOTA; magnificent 16th century churches and quaint Spanish colonial buildings in QUITO, with a drive past the snow-capped

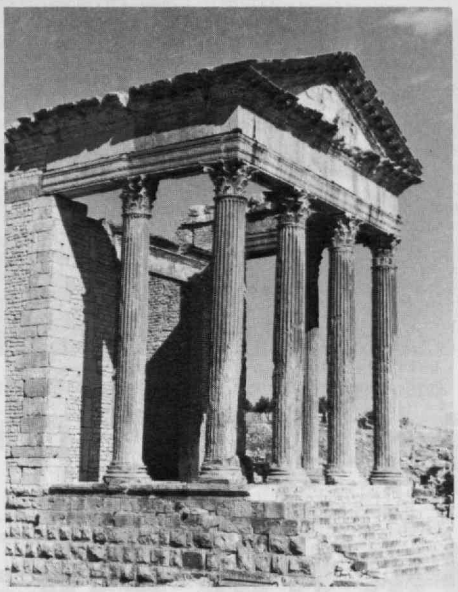
peaks of "Volcano Alley" to visit an Indian market; the great viceregal city of LIMA, founded by Pizarro, where one can still see Pizarro's mummy and visit the dread Court of the Inquisition; the ancient city of CUZCO, high in the Andes, with an excursion to the fabulous "lost city" of MACHU PICCHU; cosmopolitan BUENOS AIRES, with its wide streets and parks and its colorful waterfront district along the River Plate; the beautiful Argentine LAKE DISTRICT in the lower reaches of the Andes; the spectacular IGUASSU FALLS, on the mighty Parana River; the sun-drenched beaches, stunning mountains and magnificent harbor of RIO DE JANEIRO (considered by many the most beautiful city in the world); the ultra-modern new city of BRASILIA; and the fascination of the vast Amazon jungle, a thousand miles up river at MANAUS. Total cost is $2100 from Miami, $2200 from New York, with special rates from other cities. Optional pre and post tour visits to Panama and Venezuela are available at no additional air fare. Departures in January, February, April, May, July, September, October and November 1974.



THE SOUTH PACIFIC

29 DAYS $2350

An exceptional and comprehensive tour of AUSTRALIA and NEW ZEALAND, with optional visits to FIJI and TAHITI. Starting on the North Island of New Zealand, you will visit the country's major city of AUCKLAND, the breathtaking "Glowworm Grotto" at WAITOMO, and the Maori villages, boiling geysers and trout pools of ROTORUA, then fly to New Zealand's South Island to explore the startling beauty of the snow-capped SOUTHERN ALPS, including a flight in a specially-equipped ski plane to land on the Tasman Glacier, followed by the mountains and lakes of QUEENSTOWN with a visit to a sheep station and a thrilling jet-boat ride through the canyons of the Shotover River. Next, the haunting beauty of the fiords at MILFORD SOUND and TE ANAU, followed by the English charm of CHRISTCHURCH, garden city of the southern hemisphere. Then it's on to Australia, the exciting and vibrant continent where the spirit of the "old west" combines with skyscrapers of the 20th century. You'll see the lovely capital of CANBERRA, seek out the Victorian elegance of MELBOURNE, then fly over the vast desert into the interior and the real OUTBACK country to ALICE SPRINGS, where the ranches are so widely separated that school classes are conducted by radio, then explore the undersea wonders of the GREAT BARRIER REEF at CAIRNS, followed by a visit to SYDNEY, magnificently set on one of the world's most beautiful harbors, to feel the dynamic forces which are pushing Australia ahead. Optional visits to Fiji and Tahiti are available. Total cost is $2350 from California. Departures in January, February, March, April, June, July, September, October and November 1974.



MEDITERRANEAN ODYSSEY

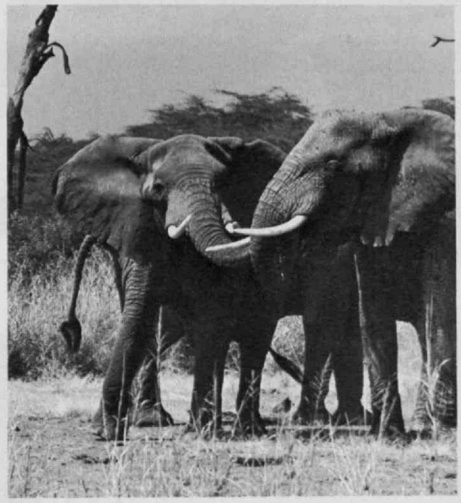
22 DAYS $1450

An unusual tour offering a wealth of treasures in the region of the Mediterranean, with visits to TUNISIA, the DALMATIAN COAST of YUGOSLAVIA and MALTA. Starting in TUNIS, the tour explores the coast and interior of Tunisia: the ruins of the famed ancient city of CARTHAGE as well as the ruins of extensive Roman cities such as DOUGGA, SBEITLA, THUBURBO MAJUS and the magnificent amphitheater of EL DJEM, historic Arab towns and cities such as NABEUL, HAMMAMET, SOUSSE and KAIROUAN, the caves of the troglodytes at MATMATA, beautiful beaches along the Mediterranean coast and on the "Isle of the Lotus Eaters" at DJERBA, and desert oases at GABES, TOZEUR and NEFTA. The beautiful DALMATIAN COAST of Yugoslavia is represented by SPLIT, with its famed Palace of Diocletian, the charming ancient town of TROGIR nearby, and the splendid medieval walled city of DUBROVNIK, followed by MALTA, with its treasure house of 17th and 18th century churches and palaces, where the Knights of St. John, driven from the Holy Land and from Rhodes, withstood the epic seige of the Turks and helped to decide the fate of Europe. Total cost is $1450 from New York. Departures in March, April, May, June, July, September and October, 1974 (additional air fare for departures in June and July).

EAST AFRICA

22 DAYS $1799

The excitement of Africa's wildlife and the magnificence of the African landscape in an unforgettable luxury safari; game viewing in the wilderness of Kenya's Northern Frontier district at SAMBURU RESERVE; a night at world-famous TREETOPS in the ABERDARE NATIONAL PARK; the spectacular masses of



pink flamingos at LAKE NAKURU; multitudes of lion, zebra, wildebeest and other plains game in the MASAI-MARA RESERVE and the famed SERENGETI PLAINS; the great permanent concentrations of wildlife in the NGORONGORO CRATER; tree-climbing lions along the shores of LAKE MANYARA in the Rift Valley, photographing rhino and other big game against the majestic snow-covered background of Mt. Kilimanjaro in the AMBOSELI RESERVE; and the vast and fascinating wilderness of TSAVO NATIONAL PARK, renowned for its elephant and lion and for the unusual desert phenomenon of the Mzima Springs. There is also a stay in NAIROBI, the most fascinating city in East Africa, as well as features such as a visit to a MASAI MANYATTA to see tribal dancing and the tribal way of life. Total cost is $1799 from New York. Optional visits are available to the VICTORIA FALLS, to UGANDA, and to ETHIOPIA. Departures in January, February, March, May, June, July, August, September, October, November and December 1974 (extra air fare for departures in June, July and August).

* * *

Rates include Jet Air, Deluxe Hotels, Most Meals, Sightseeing, Transfers, Tips and Taxes.

Individual brochures on each tour are available, setting forth the detailed itinerary, departure dates, hotels used, and other relevant information. Departure dates for 1975 are also available.

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The First Line

Technology and Energy

No remarkable prescience was needed to know that articles on energy resources would be timely in 1973 and 1974: we did not need an Arab oil embargo, raising the energy problem to "crisis" proportions, to know that, through energy, technology would in the immediate future have its greatest impact on human affairs.

The series which begins in this issue with papers by David C. White, Edmund A. Nephew, and Walter E. Morrow, Jr., will be continued in January and February with:

—"Key Issues in Offshore Oil," by John W. Devanney, III, M.I.T.
—"Oil Shale and the Energy 'Crisis'," by Gerald U. Dinneen and Glenn L. Cook, U.S. Bureau of Mines
—"Options for Energy Conservation," by Bruce Hannon, University of Illinois
—"Energy in Packaging and Marketing," by R. Stephen Berry and Hiro Makino, University of Chicago
—"Energy Efficiency in Transportation," by Richard A. Rice, Carnegie-Mellon University

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1. Sales through dealers and carriers, street vendors, and counter sales	76	56
2. Mail subscriptions	47,819	46,932
C. *Total paid circulation*	47,895	46,988
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1. Samples, complimentary, and other free copies	1,216	1,233
2. Copies distributed to news agents, but not sold	0	0
E. *Total distribution*	49,156	48,221
F. *Office use, left-over, unaccounted, spoiled after printing*	1,356	5,979
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I certify that the statements made by me above are correct and complete. s/Joseph J. Martori, Circulation Director

Letters

When Bias Is Inappropriate

The subject of nuclear energy, especially when the Atomic Energy Commission is concerned, is undoubtedly controversial. Thus, it is important that a publication such as yours report both sides of the story or avoid the subject entirely.

Two anti-nuclear (or at least anti-nuclear-establishment) books were selected for review in your July/August issue (*"Serious Trouble for the A.E.C.?" pp. 9, 74-75*), and that is understandable. However, you should have selected an unbiased reviewer instead of the openly anti-nuclear Professor Henry W. Kendall; or two reviewers should have been used so that both sides of the story are told.

The bias of Professor Kendall is readily apparent; he even goes beyond the scope of the books he is reviewing and points out his view of A.E.C. problems. I believe that book reviews should adhere to the book being reviewed and not become a platform from which the reviewer can proclaim his own views of world problems.

Charles L. Larson
Sunnyvale, Calif.

The Richness of Urban Trees

There is sound advice in Ruth S. Foster's list of obstacles to good tree growth in the city environment (*see "Plants and the Urban Ecosystem, July/August, pp. 9-10*). However, one serious popular fallacy is perpetuated by her suggestion of the use of a variety of plants in the city to minimize the effects of disease. While this may be good ecology in nonurban areas, the demands and constraints of the city often rule out all but one species of tree for a given set of requirements. In my experience most cities in temperate zones have one species of shade tree that is vastly superior in adaptability and tolerance of the city growing conditions to any other species. To intermingle the weaker, inferior species as a hedge against tree losses from disease is indeed questionable.

Many of the great urban spaces of the world bear testimony to the wisdom of using a single species that has survived intact in groves for over a century. Furthermore, if this kind of ecological reasoning were applied universally in cities we would be denied the superb unifying experience of giant rows of plane trees along the Tiber in Rome, the powerful beauty of the chestnut trees along the Champs Elysees in Paris, and the magnificent thrill of the olive groves in Mediterranean cities, to mention only three examples. Our urban people may be denied some of the richest experiences in life if we hastily allow new ecological theories to supplant the wisdom acquired through centuries of observation.

Henry F. Arnold
Princeton, N.J.

Ms. Foster adds a fourth example, and a comment: . . . and the elm-lined Common. However, a good city landscape program certainly should include a variety of design treatments from naturalistic areas to grand boulevards.

Another Wild (?) Alternative

Since reading Richard Rice's article (*"How to Reach that North Slope Oil," June, pp. 8-18*), I have not been able to make me free of thoughts upon the enormous request of money it would mean to fulfil any of the discussed alternatives—and also the danger connected to the transport of such large quantities of oil from north to the center of the U.S.

Is it not a more easy way and of less cost, too, to burn that oil up in the Prudhoe Bay region by using ship units equipped with the most modern refinery equipments, steam generators, turbines, and electric power generators. From this enormous power plant, built up in a rationalized manner in the southern part of the U.S. where the big shipyards are located and then transported up to the Prudhoe Bay region, the electrical power has to be transmitted to the center of the U.S. in a big electrical power line, designed for a high-voltage transmission.

This is my idea presented in few words—and if it is not too "wild" and possible to realize, it will of course require a good smoke-cleaning system in order to protect the polar region from the sulphur in the smoke. However, I would guess that such a smoke-cleaning system does probably not be so sophisticated as it need to be down in the center of the country.

As far as I understand, a lot of aspects are speaking for such a flexible power plant system: a reduced investment, and simplified maintenance. When the oil source in this region is empty, the power plant can easy be transported to other new oil fields developed in the region—and used until it is totally worn out.

Carl E. Johnsson
Johanneshov, Sweden

If You Would Marvel at the Ear, Consider the Eye

Dr. Siebert's analysis of signals and noise in sensory systems (*Signals and Noise in Sensory Systems," May, pp. 23-29*) was unfortunately limited in scope to the first stages of detection systems, thus overlooking the truly remarkable capabilities which biological systems exhibit for *processing* information about their environment. To start with his example: the efficiency of detection of a pure tone in the presence of noise is, in my opinion, a poor criterion of audio signal processing performance. Such signals are extremely rare in nature and, when present, normally convey no useful information. If, for reasons of reproducibility, such a crude test is the only one deemed valid, then at least let the retrieval of interesting information be part of the test: present experienced amateur radio operators with intelligible Morse code text in the presence of noise, and measure how well the information is retrieved.

The "ham" is accustomed to situations in which noise may obscure the presence or absence of individual bits in the data stream, but his *overall* signal processing has been self-trained to retrieve information. A better test would be the detection of human speech, or a baby's cry (or the bark of a dog or snap of a twig, etc.) in

Continued on p. 77

Now our 46A3 multiplex lets you put more of your money into communications, less into concrete.

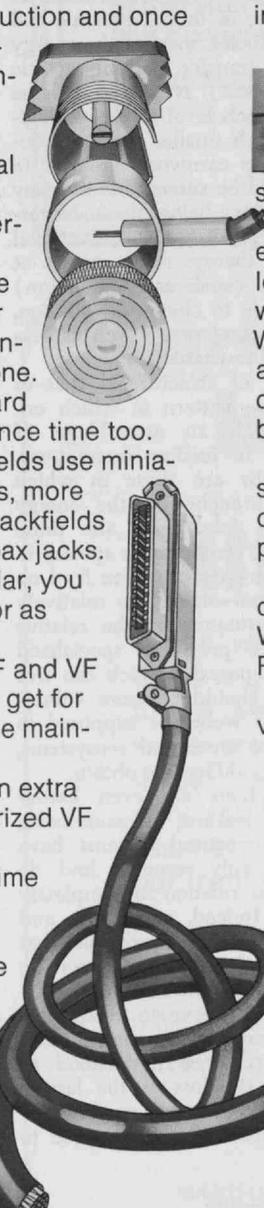
Since our new 46A3 has shrunk 600 multiplex channels to fit into three 11½-foot racks (or four 9-foot racks—your option) you might naturally assume that floor loading has gone way up. It hasn't.

So now you can use your costly floor space more efficiently and put your money where it counts; in equipment, not concrete.

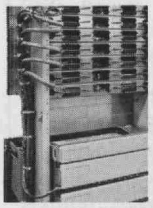
No new power plants either. Our 46A3's power requirements are way down.

Our little patented polylithic crystal filter deserves triple credit: once for that dramatic overall size reduction, once for cost reduction and once again for the high reliability, quality performance and versatility of our 46A3.

Speaking of patented items, there's a patent pending on our coaxial connector. It simplifies installation so much we use it for both intra- and inter-bay wiring.



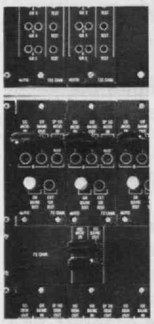
But, coaxial connectors aren't the only simplification of 46A3 wiring. Our



factory-wired racks cut installation costs to the bone. They go a long way toward reducing your maintenance time too.

Since our VF jackfields use miniature tip-ring-sleeve jacks, more space is saved. The HF jackfields also save space by using miniature coax jacks. And since the HF jackfields are modular, you can equip your system with as many or as few as you need.

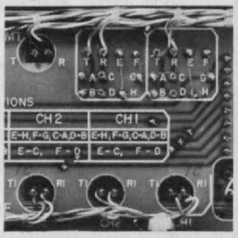
Of course, a big advantage of HF and VF jackfields is the complete access you get for



fast in-service and routine maintenance testing.

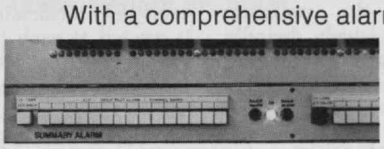
We've even taken an extra step: Optional connectorized VF jackfields reduce drop-connection installation time by as much as 50% and minimize cable wiring errors. Tell us what cable length you need (from our connectorized multiplex to your distribution frame) and that's that.

Of all these innovations, the one that you might find most exciting is the 46A3's factory-wired standard assemblies based on a modular, plug-in concept. Combine these standard assemblies with strapping options and you have a highly flexible system designed to accommodate a variety of users and multiplex applications.



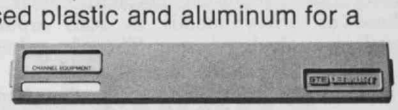
Channel strapping options are clearly and completely identified on the back of the shelves for fast, error-free installation.

With a comprehensive alarm system and full-time monitoring;



normal operations, routine maintenance, troubleshooting and service restoral are as fast as they are easy.

But, all the 46A3's improvements haven't been electronic. We've used plastic and aluminum for a lower-cost, lighter-weight package.



We've even included attractive snap-on plastic covers for the front and back of the shelves. They give you added safety as well as better appearance.

Another non-electronic improvement: Our standard assemblies have simplified engineering and ordering, making it possible to offer you a volume price structure.

So, before you make any multiplex decision, contact us for more information about our 46A3. Write GTE Lenkurt, Department C134, 1105 County Road, San Carlos, CA 94070.

We have a rackful (or, rather three racks full) of very pleasant surprises for you.

GTE LENKURT

Ecosystems Under Stress

Environment/Technology
by
Ian C.T. Nisbet

A free lesson in pollution ecology is available to anyone who cares to drive through Sudbury, Ontario. A group of smelters near the town is probably the largest point source of sulphur dioxide in the world, and has ravaged the vegetation for miles around. As one travels towards the source, the number of damaged and dead trees steadily increases, until all are gone and the forest gives way to shrub-covered heath. Continuing up the pollution gradient, the shrubs progressively dwindle until only herbs and grasses remain. Finally, a mile or so from the smelters, the moon-like landscape can hardly support any plants at all.

The same sequences of vegetation—trees, shrubs, herbs, grasses—can be seen along other pollution gradients, such as those of heavy metals in soils around smelters and slag heaps. They long have been familiar along natural gradients of chemical stress, such as copper gradients in serpentine soils, and of physical stress, such as temperature gradients on mountain-sides, or moisture gradients on sand-dunes. On a global scale, the latitudinal zones of vegetation follow the same sequence, from tropical rain forest to arctic tundra. Human disturbance, such as grazing, fire, and agriculture, leads to similar sequences of vegetation. They also produced by a radiological stress, in an experimentally irradiated forest at Brookhaven National Laboratory.

When an ecosystem is impoverished in this way, its ability to perform some ecological functions, such as the fixation of solar energy and the retention of moisture and nutrients, is generally reduced. We are thus led to the principal generalization of pollution ecology: under increasing stress, natural ecosystems suffer a progressive impairment of structure and function.

This generalization is appealingly simple, but as a predictive tool it lacks specificity, and conveys no quantitative idea of the relation between stress and strain. Most seriously, perhaps, it still lacks an adequate basis in biological theory.

Complexity and Vulnerability

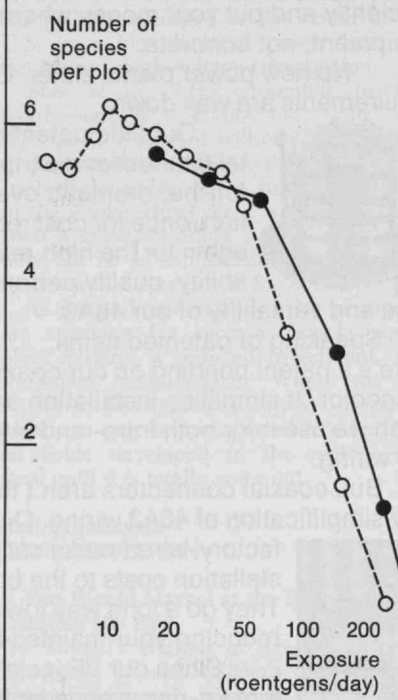
At the level of the individual organism, the relation between complexity of structure and vulnerability to stress is fairly easy to understand. Large, complex organisms have to devote a relatively large amount of energy to self-maintenance and have little reserve capacity for repair of damage. Species with complex life-histories, or those which depend on a number of others for essential resources, have many critical functions that are vulnerable to stress.

"Structure" of an ecosystem has more than one meaning, however. One is "trophic" structure: the way in which energy fixed by plants is passed up food webs through herbivores to a succession of carnivores. Because of thermodynamic and ecological inefficiencies, most of the energy is wasted at each transfer and only a little (roughly 10 percent) is passed to the next level. Thus each level in the ecological pyramid is much smaller than that below it, and the top carnivores are few in number and should be susceptible to many kinds of perturbations below them. Nevertheless, we can point out observational exceptions to the theory: some species at low trophic levels (such as zooplankton) are very susceptible to chemical pollution, while some high carnivores (such as seagulls) appear very resistant.

Another aspect of structure is that of the food web—the pattern in which energy flows through an assemblage of species by means of feeding interactions. Diverse food webs are those in which there are many branches in the energy pathways; simple food-webs are those with few branches. In theory, a species in a diverse food web—one that can feed on a number of others—should be relatively unaffected by fluctuations in the relative abundance of its prey. A specialized species, such as a parasite which can live in only one host, should be more vulnerable. Diverse food webs are supposed to be characteristic of unstressed ecosystems, but precise data are difficult to obtain.

Ecosystem functions are even harder to define and measure. Measurements of productivity in natural systems have become available only recently, and do not show any clear relation to complexity or lack of stress. Indeed, agriculture and forestry are based on the principle that artificially simplified ecosystems can be made more productive than natural ones.

Stressed systems appear to retain nutrients less efficiently than undisturbed systems, but this can be understood as a consequence of the loss of the larger, sensitive species. We do not need to invoke special properties that are unique to complex systems.



One measure of the richness of an ecosystem is the number of different species it contains. Pollution causes impoverishment, and radiological stress turns out to have similar effects. This chart, from research by George M. Woodwell at Brookhaven National Laboratory, shows how the amount of irradiation from a single gamma-ray source over a two-year period affected the number of species in test plots near Brookhaven. The solid line shows the situation in 1962 after one year of irradiation. The dashed line in 1963, after two years.

Complexity and Stability

Most ecologists accept that there is some relationship between the complexity of an ecosystem and its stability. "Stability," however, is difficult to define precisely in natural systems with large fluctuation levels. It is hard to perturb a forest and measure its rate of recovery, both because the initial state is ill-defined and because the natural time-scales are very long. In theory, diverse food webs ought to be more stable than unbranched food chains, because the redundancy of energy pathways allows the system to function even if some pathways are temporarily broken.

Diversity has two aspects, however: the number of species and the number of cross-links. A recent computer experiment suggests that increasing the number of cross-links actually promotes instability. On statistical grounds alone, adding more species to a system without increasing the amount of cross-linking would be expected to reduce the overall level of fluctuation. It is quite likely that inter-species interactions promote stability in nature, but this still awaits satisfactory demonstration.

In the past, ecological theorists talked vaguely of ecosystems evolving towards stable states of maximum diversity and complexity. Analogous theories today refer to trends towards increasing minimum entropy, maximum information content, or maximum efficiency. One school regards the flow of energy through ecosystems as a self-organizing principle. Some of these theories border on teleology; others do little more than restate old problems. Practical ecologists, while respecting the need for generalizations, have not yet found these theories of predictive value.

A Disorganizing Principle

Unfortunately there is one general principle in ecology which subsumes all others. Natural selection acts at the individual level, favoring the development of those traits that enable an individual to raise more offspring than others of its species. This continual rewarding of individual enterprise undermines any organizational tendencies at the ecosystem level: it favors those who find loopholes in the existing system or cheat on their neighbors. There are obvious analogies in social systems.

We can perhaps develop this idea into a generalization, an ecological equivalent of Murphy's Law: any general principles of ecosystem behavior will go wrong. It is this maddening individualistic behavior of systems at the microscopic level that makes ecology (and social science) so difficult.

To provide the answer to practical problems that always are needed before there is time to gather adequate evidence, applied ecologists must rely on shrewd use of erroneous generalizations, combined with an intuitive feeling for exceptions.

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Maritime Miners Race Past Seabed Diplomats

Science-at-Large
by
Peter Gwynne

Throughout this turbulent year, the question of sovereignty over the seas has rarely been out of the newspaper headlines. In the azure Mediterranean waters, U.S. and Soviet fleets steam warily past each other. In the frigid North Atlantic, Iceland, Great Britain, and West Germany are engaged in a classic diplomatic confrontation over fishing rights within 50 miles of the Icelandic shore—a confrontation whose diplomacy occasionally escalates into the gunboat variety. And this past summer, as delegates in Geneva were laboriously debating the pros and cons of international control of the high seas, an oceanographic ship Glomar Explorer slipped quietly out of the Sun Shipbuilding Company dock in Philadelphia on a venture that could cause considerably more international recriminations and repercussions.

The object of the vessel's trip is to seek and mine a stupendous trove of mineral-rich manganese nodules lying on the seabed at depths between 12,000 and 20,000 feet, in waters beyond any nation's territorial claims. And, pointedly, the Glomar Explorer is operated by a company owned by an eccentric billionaire who is, in the view of many observers, setting off a rush for underwater exploitation that could make the industrialization of the American west look like a well-disciplined military maneuver.

Manganese nodules—black, potato-shaped rocks that cover much of the seabed in great profusion—were first hauled up about a century ago, by the British oceanographic ship H.M.S. Challenger. Only over the past two decades have they really evinced major interest among ocean experts and industrialists. The interest stems from the nodules' chemical composition, roughly 20 per cent manganese, and 1½ to 2 per cent copper, cobalt, and nickel. Manganese is a critical metal in manufacturing all forms of steel, while cobalt and nickel are widely used in certain types of steel. At present the U.S. imports 98 per cent of its manganese, 92 per cent of its cobalt, and 84 per cent of its nickel, mostly from Communist nations, such as the Soviet Union and the People's Republic of China, and unstable third-world countries such as Zaire and Zambia.

Strategically, this is a far-from-satisfactory situation for the U.S. and other western countries without indigenous supplies of those vital metals. In recent years companies in the U.S., West Germany, Japan, and other nations have mounted a large-scale effort to develop the necessary technology for economically mining and processing the seabed nodules, whose overall value to successful exploiters is roughly estimated at $6 billion per year.

Dredging and Hedging

About two years ago, it became clear that the Hughes Tool Company, Deepsea Ventures, and Kennecott Copper, among other American firms, had developed the basic technology sufficient to start mining the nodules. (The technology involves a giant vacuum for extraction from the seabed and a water-leaching process for isolating the individual metals from the nodules.) The companies bided their time, however, awaiting some ruling on ownership of and authority over the seabed areas covered by the nodules.

Ownership and authority has been the subject of interminable international jamborees, and will once more figure prominently in a major Law of the Sea conference next spring in Santiago, Chile. The industrialized nations argue that a substantial portion of the profits derived from manganese-nodule mining should go to the exploiters. They are opposed by nations of the third world who insist that seabed manganese is a resource shared by the world's nations and that the profits should be channeled by an international body predominantly to those most desperately in need of funds—the developing nations.

The approach of the industrialized nations calls for a relatively simple system of leasing blocks of seabed to individual companies, rather after the model of the North Sea oil and gas fields. Companies buy from some appropriate international body the right to seek manganese nodules in their blocks, and upon finding economical amounts they would pay the same body royalties.

The third-world strategy differs markedly. Exploitation of the nodules would be carried out by an international organization, which would presumably buy equipment and expertise from companies already involved in the field, but which would divide up the profits among nations in financial need—especially those nations such as Zambia and Zaire that could suddenly find themselves in a kind of competition over the new source of minerals.

Diplomatic Dodderers and Seabed Squatterers

To date, the U.S. oceanographic com-

Illustration by Charles Hefling

panies' caution has been understandable. It is quite possible that a company might set up its nodule process and then be forced out of the business by an international agreement demanding excessively high royalties or be taken over altogether by a new international organization. In one effort to protect themselves against either of these eventualities, the companies promoted a congressional bill that would have forced the U.S. government to insure them against losses in seabed mineral exploitation. However, the bill was so obviously a case of special pleading that it was in effect killed in the Senate, and eventually achieved no more than convincing developing nations that the U.S. was embarking on an era of what they have called "maritime colonialism."

For all its clumsiness in lobbying, the oceanographic establishment does have a good case for hurrying along the mining of the nodules. To date, U.S. technology has been plainly superior to that of other nations, but as the U.S. companies chomp at their bits, companies from other nations, many of them government-supported, have been catching up. The risk, as U.S. government officials concede, is that once a company from another nation decides to go ahead with marine mining, it may create a near-monopoly and force this country to continue importing manganese, nickel, and cobalt.

Hence the Hughes Tool Company venture. And by the time the Santiago Law of the Sea Conference opens—if it is not postponed owing to lack of progress in the preparatory sessions—the Glomar Explorer may be actually mining nodules a few hundred miles off Hawaii. Unfortunately, the reaction of delegates to that possibility is hardly likely to be different from the Geneva delegates' reactions to the Glomar Explorer's departure. They tut-tutted, accused the Hughes empire of everything from piracy to bad sportsmanship, and returned to their squabbles.

Perhaps the only hopeful note about the whole affair is that there is still a little time to resolve the issue of sovereignty. Even if the Glomar Explorer strikes a rich manganese deposit first time, its crew will still have to optimize methods of bringing the nodules up, and scientists on land will have to develop appropriate techniques for processing the metals in bulk. In that time, delegates could agree at least to some form of international control of the mining operations. But the signs are that they will not. Diplomats who could not compromise when the threat of nodule exploitation was far in the future seem no more likely to agree now that the technology has caught up with them. Indeed, many seem hardly to recognize the fact that the exploitation technology is available.

Thus, the most likely prospect over the next few years seems to be a neck and neck race among companies from various nations to stake out their claims on the seabed like so many squatters.

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Even before the disruption of oil supplies from the Middle East elevated the issue to "crisis" proportions, the evidence was clear: a complex series of interrelated factors was bearing down on an industrial world which had never been inhibited in its consumption of energy

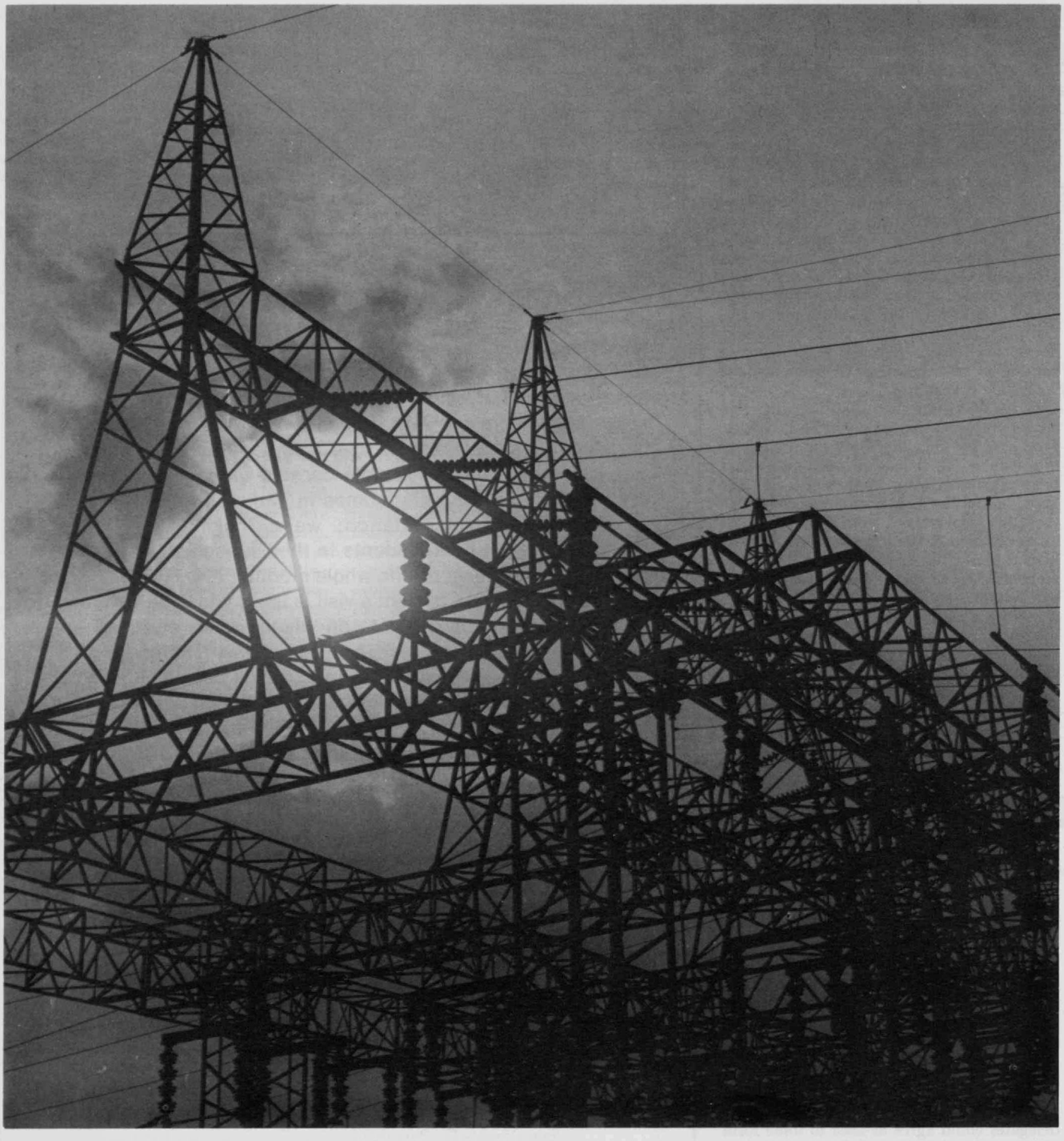


Photo: Underwood & Underwood

David C. White
Ford Professor of Engineering;
Director of the Energy
Laboratory, M.I.T.

The Energy-Environment-Economic Triangle

The nation's widely-publicized "energy crisis" arises from a number of concurrent developments, and it is this fact which makes energy planning so difficult and energy policy so controversial. Predominant in the present situation (excluding the sudden current oil interruption by the Arab states) is the enormous volume of energy now being consumed—and the exponential growth rate of energy use. This summer's gasoline shortages and this winter's potential fuel oil shortages are caused by increases in the growth rate of demand that represent only a few percentage points (see page 12) but in physical units represent many millions of barrels of products. The capacity to supply, process and deliver unanticipated demand of this magnitude is a characteristic problem of large-volume, capital-intensive systems having long planning lead times, i.e. all sectors of the energy system.

Major environmental impacts are another symptom of the "crisis" resulting from the large amounts of energy supplied and consumed. Whenever energy is used, pollutants are released that are either detrimental or unpleasant for mankind. Some of these pollutants are influencing the total biosphere in unknown and possibly injurious ways, unpredictable over the long term with today's knowledge. Pollutants somewhat analogous to those produced in consuming energy are also the result of supplying and processing energy. The large volume of basic fuels that must be handled (for example, 6 billion barrels of oil per year) means that accidental contamination of the environment is also highly probable—although our present experience is a very low rate considering the volumes of materials handled.

Shortages of fuels and of energy itself are also an issue in the "crisis." The magnitude of present consumption is so great that depletion of our most desirable and easily obtainable domestic fossil fuels is becoming a significant problem. The absolute amounts of fuel resources are not today at issue, since for all fuels only a small fraction of the total resources in place have been drawn upon to supply our energy from antiquity to the present. But a continuing exponential growth in energy consumption at anywhere near the historic growth rate (approximately a 20-year doubling time) superimposed upon the present magnitude of consumption raises the possibility that we will exceed our capability to supply our needs from domestic resources of economically obtainable fossil fuels even with major improvements in technology. Indeed, at today's increasing rate of consumption another century of low-cost domestic fossil fuels may not exist. Domestic nuclear fuels are available in immense quantities, but their long-term adequacy and sensible resource conservation depend on successful development of new technology including breeder and fusion reactors and usefulness in the resolution of the safety and waste management problems which now introduce uncertainty and disagreement, even among experts, on the future of fission processes.

In short, depletion of economical and environmentally acceptable fossil fuel resources, increasing daily environmental disturbances, and long-term disruption of the total ecosphere are highly probable consequences of our present energy practices. This alone would be a sufficient explanation for our sense of crisis.

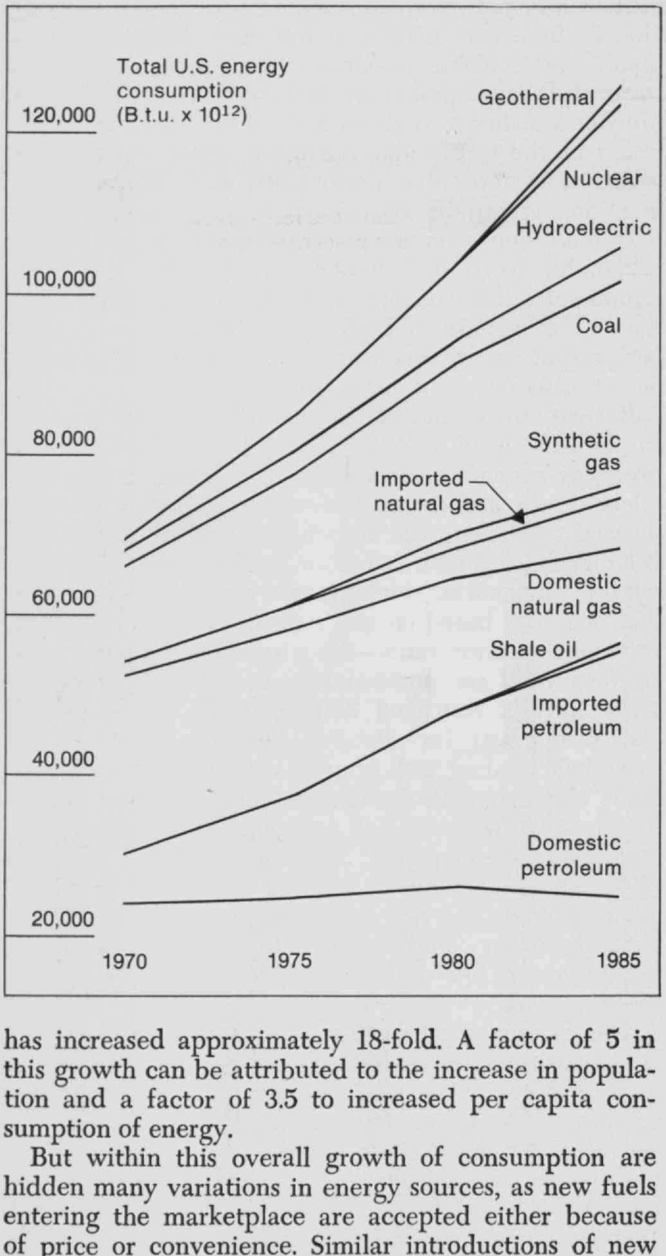
But we now understand as well that the marketplace can be influenced by many factors including regulatory practices, economic uncertainty, or political actions that affect supply and demand much more quickly than industrial technology can respond with research and development (and their reduction to practice) in physical science, engineering, biology, or ecology. And we know that decisions based on cost-benefit analyses at current economic interest rates—though they may yield conclusions valid for profit-making industries that necessarily have a restricted domain of concern—are not necessarily best for society's long-term interest nor capable of dealing with future uncertainties. So we conclude that major institutional revisions to allow proper interactions between the economic marketplace, research and development, and the long-term interests of society—each with a different constituency having different goals and different dynamic response characteristics further complicated by high degrees of uncertainty—are a first requirement for dealing with the "energy crisis."

The "energy crisis" is usually perceived in terms of symptoms, not causes. Today's problems are the result of limited forward vision complicated by uncertainty, resulting in many poor decisions made in the present and past decades. Unless today's approaches can look decades ahead, introduce enough options to give flexibility so as to minimize the effects of uncertainty and change, and at the same time deal with today's problems, the "energy crisis"—no matter how defined—will continue and even increase in severity.

Energy Supply and Consumption

The energy consumed in the United States has grown steadily over most of its history and in the last 100 years

U.S. energy consumption in 1970 was just over 67,000 trillion B.t.u.; if present trends continue, the National Petroleum Council estimates that by 1985 the country will be using just short of 125,000 trillion B.t.u.s annually. The difference is 55,000 trillion B.t.u.s of new energy to be supplied in the 15-year period, and the National Petroleum Council believes that 37,000 trillion B.t.u.s of this increase will come from imports of petroleum and (liquified) natural gas—unless markedly higher prices for petroleum products are encouraged by national energy policy.



has increased approximately 18-fold. A factor of 5 in this growth can be attributed to the increase in population and a factor of 3.5 to increased per capita consumption of energy.

But within this overall growth of consumption are hidden many variations in energy sources, as new fuels entering the marketplace are accepted either because of price or convenience. Similar introductions of new fuels into the energy supply system should be one of the goals of new research and new technology in the future.

New energy fuels have characteristically grown with a nominal doubling time of 10 years until they have established their share of the energy market. This characteristic growth occurred for coal in the last three decades of the 1800s, for oil during the first three decades of the 1900s, and for natural gas from the 1930s onward—and still growing. (See "An Agenda for Energy" by Hoyt C. Hottel and Jack B. Howard, January, 1972, pp. 38-48). The use of electricity (generated using these primary fuels) has been doubling every 10 years for 70 years, and this trend continues unabated.

By 1972 these trends had together resulted in an annual energy consumption of 71.5×10^{15} B.t.u.s. for the U.S., obtained—according to the British Petroleum Co's 1972 *Statistical Review of the World Oil Industry*—from the following primary fuels:

Oil	44.4% or 5.7 billion bbl.
Natural gas	31.8% or 22.8 trillion ft.[3]
Coal	18.6% or 49.0 million tons
Hydro	4.1%
Nuclear	1.0%
Electricity	generated from the above, consuming 25% of this total energy and delivering 1.7 trillion kwh.

In terms of growth rates, the 100-year average has been 3 per cent annually, but in the decade 1962-1972 energy consumption averaged 4.1 per cent annual growth, with the last three years being: 1970—3.8 per cent; 1971—2.3 per cent; and 1972—3.6 per cent. Projections to the year 1985 made by the National Petroleum Council show growth rates varying from 3.4 per cent to 4.4 per cent; the projected estimate of 4.2 per cent, yielding a consumption of 125×10^{15} B.t.u. by 1985, is chosen as the most likely.

Many factors including rising prices, shortages, and a national conservation program have a high probability of drastically modifying these future projections. Consider, for example, the consumption of petroleum: the increase in 1972 over 1971 was 7.9 per cent, while 1971/1970 was 3.6 per cent and 1970/1969 was 4.0 per cent. The doubled growth rate in petroleum consumption in 1972 was stimulated in large measure by the Clean Air Act. It is a direct contributor to the current oil shortages, and this fact emphasizes the tight coupling between energy and the environment that must be recognized and planned for in a well-managed energy system.

The resource base from which the primary energy comes, of which 95 per cent in 1972 was fossil fuels, is

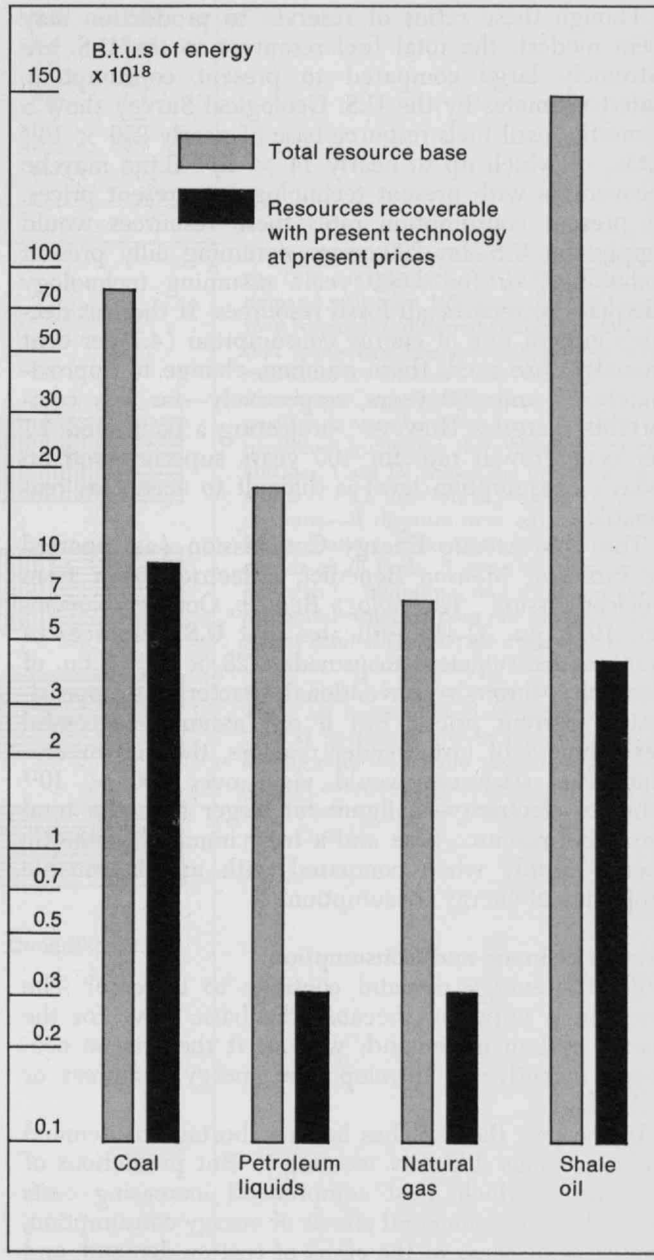
to a large degree (84 per cent) from domestic sources. Natural gas imports from Canada and overseas in 1972 were only 1.0 trillion $ft.^3$, or 4.4 per cent of the total consumption of 22.8 trillion $ft.^3$. Oil imports were substantially larger—1.8 billion barrels out of a total of 5.7 billion bbl., or 32 per cent. On an energy basis these two fuel imports amount to 11×10^{15} B.t.u.s. of energy, a foreign dependence for 16 per cent of U.S. energy sources in 1972.

Estimates by the National Petroleum Council of domestic supply possibilities to meet a projected demand of 125×10^{15} B.t.u.s by 1985 are shown in the accompanying chart (page 12). The supply potential is strongly price-dependent with the minimum dependence (11 per cent total imports) by 1985 requiring oil at \$6.69/bbl. and gas at 43.6¢ per million $ft.^3$, both expressed in 1970 dollars. With inflation rates ranging from 3 to 4.5 per cent, these prices will be 1.5 to 2 times higher when expressed in 1985 dollars.

The domestic and international petroleum supply potential is strongly influenced by world politics, world economic stability, and U.S. domestic energy policy. Today rapid changes in world oil prices by principal oil exporting nations and an unstable Middle East are making any projections doubtful for 1974 let alone 1985. However, there is strong evidence which suggests that supplying projected 1985 demand from domestic sources will require major changes in current energy policies and in all probability sharply increased fuel prices, particularly for oil and natural gas. Indeed, it is not certain that the domestic energy supply can, at any reasonable increased prices and acceptable environmental impact, respond in the time available to a strong continuing growth of demand. The time lags in increasing energy supply through exploration or new technology are long, particularly if full attention is given to all relevant environmental impacts. Our efforts to build the Alaska pipeline to open the North Slope oil resources to U.S. markets (see "How to Reach That North Slope Oil," by Richard A. Rice, June, 1973, pp. 8-18) or to stimulate tight gas formations by nuclear explosives or other means have been frustrated by delays which are examples of what we must expect in the future when major new technologies or new environmental factors are involved in energy development.

U.S. Energy Resources

The total amount of energy fuel resources in the U.S. is a subject of considerable uncertainty, and estimates



The U.S. Geological Survey estimates that total U.S. fossil fuel resources represent nearly 250×10^{18} B.t.u. of energy; but this figure is illusory in the sense that present technology is sufficient to recover—at present prices—only about 14×10^{18} B.t.u. of this immense energy reservoir. (The recovery of energy from shale oil is less certain than from other resources; U.S.G.S. estimates range from 0.9 to 3.5×10^{18} B.t.u.) At present consumption rates the recoverable fossil resources would last some 200 years; but if 4.1 per cent annual growth in energy consumption is assumed, that period is shortened to 50 years—a "far less comfortable" margin, writes the author.

are subject to substantial error. In projecting resources it is common practice to quote reserves available at current prices and technology; but this cannot be taken as a measure of total fuel in place. Proven reserves—those which have been identified by exploration as economically producible—in the U.S. in 1971 were 45×10^9 bbls. of oil and 279×10^{12} ft.^{3} of natural gas. These reserves represent 11.1 and 12.4, respectively, times the annual production rate for these fuels. (The ratio of oil reserves to total U.S. consumption of oil (including imports) is approximately 8.1.) This ratio of reserves to production is basic among the several factors which determine the market price for fuels, and those ratios have been decreasing during the last decade because of a decrease in domestic drilling. The reasons are many, but contradictory policy and conflicting incentives play a major role.

Though these ratios of reserves to production may seem modest, the total fuel resources in the U.S. are extremely large compared to present consumption. Latest estimates by the U.S. Geological Survey show a domestic fossil fuels resource base of nearly 250×10^{18} B.t.u., of which up to nearly 14×10^{18} B.t.u. may be recoverable with present technology at present prices. At present consumption rates these resources would supply the U.S. for 200 years, assuming only present technology, or for 3,500 years assuming technology adequate to recover all fossil resources. If the last decade's growth rate of energy consumption (4.1 per cent annually) are used, these numbers change to approximately 50 and 100 years, respectively—far less comfortable margins. However, projecting a continued 4.1 per cent growth rate for 100 years superimposed on today's consumption level is difficult to accept as reasonable.

The U.S. Atomic Energy Commission (as reported by Professor Manson Benedict, "Electric Power from Nuclear Fission", *Technology Review,* October/November, 1971, pp. 32-41) estimates that U.S. resources of uranium are sufficient to provide 0.28×10^{18} B.t.u. of electricity through conventional reactors at approximately current prices. But if one assumes successful development of fast breeder reactors, the known uranium fuel resources would yield over 500×10^{18} B.t.u. of electricity—a figure far larger than the total fossil fuel resource base and a truly immense domestic energy supply when compared with any reasonable projection of energy consumption.

Energy Demand and Consumption

Will U.S. energy demand continue to increase? The question is important because the basic drive for the energy system is demand; without it there is no economic incentive to develop new energy resources or technology.

In the past the U.S. has had no shortage of demand and no serious difficulty meeting it. But predictions of the future, which must comprehend increasing costs due to the environmental effects of energy consumption, require some sense of the effect of cost on demand, and we know little of the price elasticity of the energy market. However, some insight on future energy demand can be obtained by reviewing where energy is currently consumed and what basic drives for energy consumption are likely to be operating in the near term.

The U.S. population growth rate is projected to decrease in the period from 1970 to 1985; one projection suggests that the population by 1985 will be 241 million, an increase of 38 million over 1970—which is exactly the same amount of increase over the much smaller base (from 165 million) in the 15 years from 1955 to 1970.

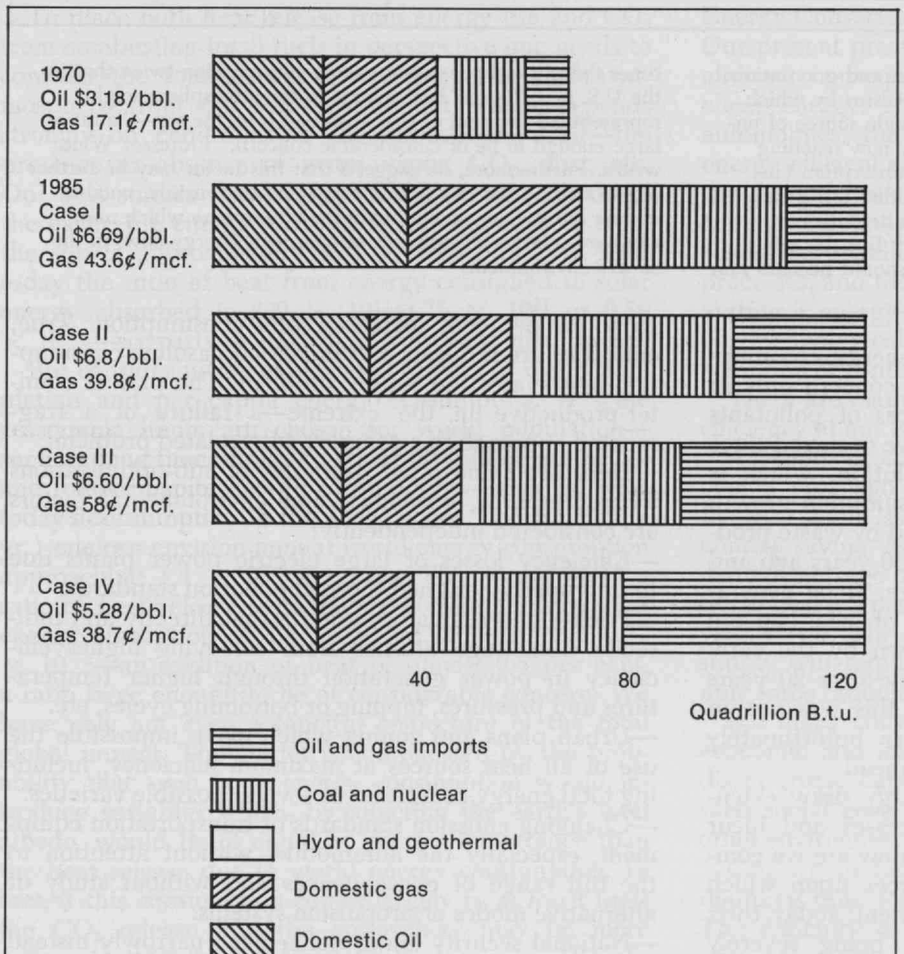
It is true that the reduction in population growth rate is of long-term significance; it will affect energy consumption growth by 1990. In the meantime, however, the crucial issue is the large number of children already born who will enter the 20-to-35-year-old group during the next 15 years: there will be a large number of family formations—in fact, over twice the growth rate in family formations that occurred from 1955 to 1970. These people will be entering that period in their lives when their energy requirements are highest; there will be major pressures on residential and transportation energy consumption, and the large number of family formations will also exert large pressures on industrial and commercial sectors for goods and services. Thus past high birth rates will be a strong stimulus to energy consumption during the next 15 years.

One significant characteristic of our pattern of energy consumption is the high growth rates associated with new uses for energy. During the 1960s, according to a Stanford Research Institute study, the high-growth-rate items in the residential use of electricity were space heating (21.6 per cent annual growth), air conditioning (14.6 per cent annual growth), and clothes drying (10 per cent annual growth). High-growth items in commercial energy consumption in the same decade were air conditioning (8.2 per cent annual growth) and illumination, commercial equipment and other (25.5 per cent annual growth). If such new uses for energy replaced other energy demand, then the growth in energy consumption would parallel population growth. But this has not been the trend to date; in the last 30 years per capita energy consumption has doubled, and present trends in all consumption sectors, particularly transportation, residential, and commercial, show continuing growth in per capita energy consumption. Indeed, this growth in energy demand correlates closely with growth in per capita income. Personal expenditures have grown at a 3.8 per cent annual compound rate during the decade of the 1960s. The annual energy consumption per unit of G.N.P. in the U.S. has been constant within $\pm$ 5 per cent for the last 20 years.

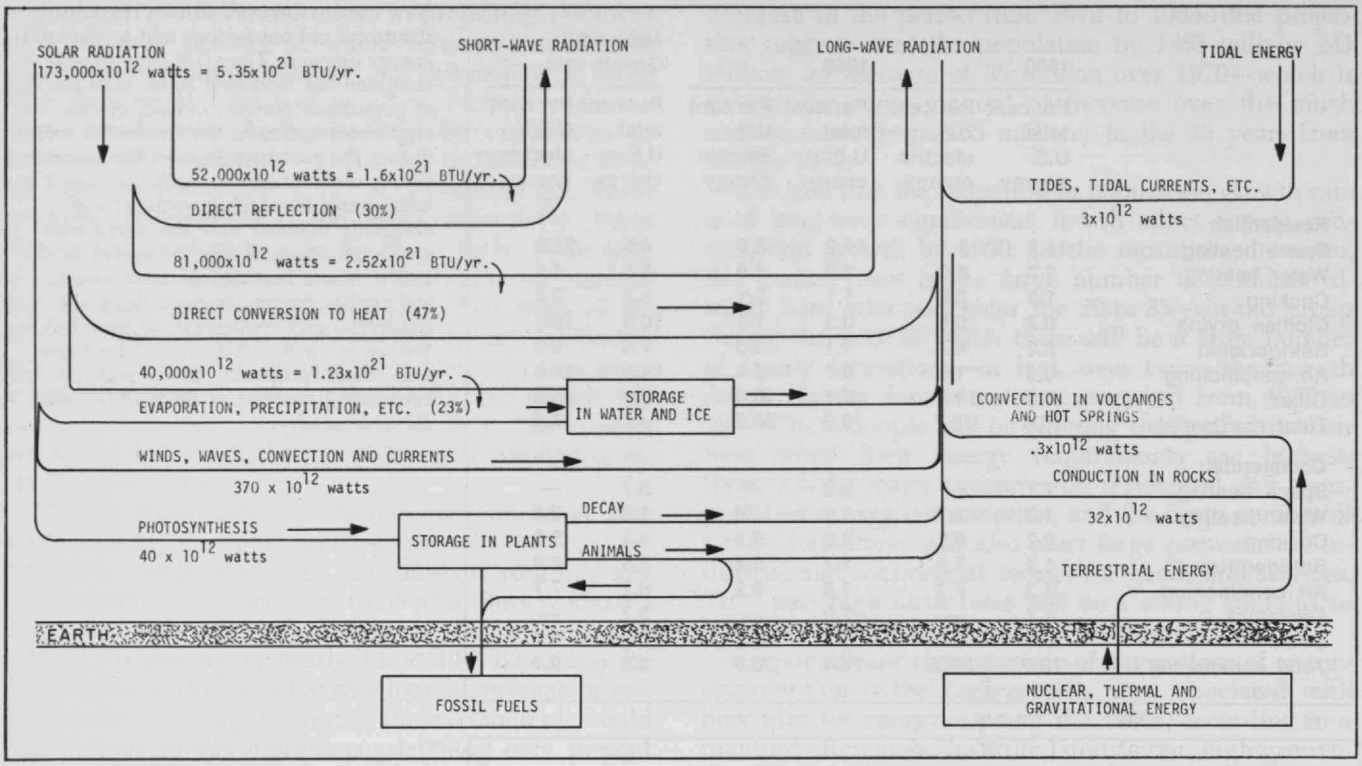
Growing use of energy accompanying growing affluence is a world-wide phenomenon. The ratio of energy consumption to G.N.P. is higher (typically by a factor of two) in an industrial economy than in an agricultural one, though in general the Communist countries of Europe and Asia have a higher energy per G.N.P. than western nations—perhaps because of differences in the productivity of men and machines, or because they are heavily involved in the establishment of basic industries that are very energy-intensive. But the conclusion seems obvious: affluence and energy consumption go hand in hand. Worldwide energy consumption is currently growing at the rate of over 5.5 per cent annually. As technological innovations already available in the developed countries are adapted to the developing countries, this growth rate will almost surely increase. The effect on the world resource base and the world environment is a matter that should be of serious concern for all nations and all societies.

	1960		1968		1960-1968 Growth rate	
	Per cent total U.S. energy	Per cent U.S. electric energy	Per cent total U.S. energy	Per cent U.S. electric energy	Per cent total U.S. energy	Per cent U.S. electric energy
Residential:						
Space heating	11.3	1.1	11.0	3.6	4.0	21.6
Water heating	2.7	6.0	2.9	4.9	5.1	4.5
Cooking	1.3	2.8	1.1	2.1	1.7	3.4
Clothes drying	0.2	0.9	0.3	1.1	10.0	10.0
Refrigeration	0.9	4.7	1.1	5.5	7.8	9.0
Air conditioning	0.3	1.9	0.7	3.4	14.6	14.6
Other	1.9	11.3	2.1	10.0	5.4	5.5
Total residential	*18.6*	*28.7*	*19.2*	*30.6*	*4.7*	*7.8*
Commercial:						
Space heating	7.2	—	6.9	—	3.7	—
Water heating	1.3	2.7	1.1	1.9	2.3	2.3
Cooking	0.2	0.2	0.2	0.2	4.4	5.9
Refrigeration	1.2	7.5	1.1	5.4	2.8	2.9
Air conditioning	1.3	7.7	1.8	8.2	8.2	7.7
Feedstock	1.7	—	1.6	—	3.7	—
Other	0.3	2.0	1.7	8.2	25.5	24.7
Total commercial	*13.2*	*20.1*	*14.4*	*23.9*	*5.3*	*9.1*

New energy sources and uses do not substitute for old ones—they add to the total energy demand. Thus U.S. energy consumption has increased faster than the rate of population growth; indeed, electric energy consumption in the residential sector during the past two decades has correlated closely with rising per capita income. The table shows that high growth rates of electricity demand were associated with new applications of electric energy in the 1960s—space heating, air conditioning, and clothes drying, for example, in the residential and commercial sectors. But as the use of electricity increased for these and other purposes, there was no corresponding decrease in demand for other forms of energy.



Trying to anticipate how the structure of the U.S. energy market in 1985 (when demand will total 125 quadrillion B.t.u.s) may respond to different fuel prices at that time—how one source of energy may substitute for another—the National Petroleum Council has projected four possible futures based on four different conditions governing the availability of oil and gas. Case IV shows the predicament which N.P.C. forecasts if present trends continue—if disputes over environmental issues continue to constrain growth in output of all fuels; if government policies prove to be inhibiting; and if oil and gas exploratory success does not improve over recent results. Case I projections are for "the most optimistic supply conditions," which N.P.C. believes are in fact unlikely. There are two intermediate appraisals: Case II postulates greater improvements in finding rates for oil and gas, and a quicker solution to problems in fabricating and installing nuclear power plants than does Case III.



With the exception only of nuclear, geothermal, and gravitational energy—the source of which is tied to the processes by which the solar system was formed—the ultimate, single source of energy on earth is the sun. How the solar energy now reaching the earth is distributed between reflection and absorption (including conversion to heat, evaporation, and other terrestrial processes) is a crucial question, and how man's activities affect this critical balance is far from understood. But this we know, writes the author: if world population should become four times today's and per capita energy consumption twice that in the U.S. in 1970, our heat release to the atmosphere might represent 0.5 per cent of that absorbed from the sun—"a ratio large enough to be of considerable concern," Professor White writes. Furthermore, he suggests that this factor may be further aggravated by the products of fossil fuel combustion, notably carbon dioxide, accumulating in the atmosphere which may cause even larger disturbance of enormous energy flows in the earth's environment.

The Environment and Energy

The environmental consequences of energy consumption have become a matter of general concern only in the last two decades. Isolated instances of pollutants strongly degrading the environment have occurred since the beginning of the industrial revolution, which is the point at which today's energy consumption growth patterns start. The London fog produced by waste products of coal consumption was familiar 50 years ago and critical enough by 1952 to force change. Smog generation in the Los Angeles basin, an item of local concern in the 1940s whose causes were known by the early 1950s, became of national concern only after 20 years had passed and it became clear that this was not an effect unique to California. These are unfortunately typical examples of our failure to plan ahead.

All suppliers and consumers of energy draw extensively on natural environmental processes and incur little or no market cost for them. Only now are we coming to realize that the natural resources upon which these processes depend are finite in extent; today their capability to absorb disturbances is being severely taxed. The era of the "free ride" is nearing an end, and the costs of today's energy production and consumption practices will soon have to be borne by all. It is also becoming clear that environmental and energy practices are part of a tightly coupled system; action treating only single ills is likely to be counter-productive.

The automobile pollution standards are one case in point. Current emission control standards result in from 15 to 30 per cent increased fuel consumption. True, emissions are reduced; but increased gasoline consumption aggravates the supply problem. The plan is counter-productive in the extreme—a failure of a fragmented approach to a complex, interrelated problem.

Here are some other examples of sub-optimizations where resource, economic, and environmental factors are considered independently:

—Efficiency losses of large electric power plants due to improperly designed thermal pollution standards.

—Pricing and regulatory criteria that directly and indirectly discourage utilities from achieving higher efficiency in power generation through higher temperatures and pressures, topping or bottoming cycles, etc.

—Urban plans and zoning which make impossible the use of all heat sources at maximum efficiency, including total energy complexes of several possible varieties.

—Changing emission standards of transportation equipment, especially the automobile, without attention to the full range of consequences and without study of alternative modes or propulsion systems.

—National security issues defined too narrowly instead of international security that considers fuels, industrial trade, environmental quality, and social welfare in a world-wide, balanced way.

One additional environmental factor needs explicit consideration. Most of today's environmental discussion revolves around specific pollutants that influence the biosphere, such as SO_2, carbon monoxide, the oxides of nitrogen, radioactive waste, and waste heat

(causing temperature rise in water bodies). Technology is—or presumably soon will be—available to control all these factors, keeping them at levels within the tolerance of the total ecosystem or at any other levels we may elect to specify, given sufficient time and at some economic cost. The increase in man's knowledge of how to reduce disruption of the environment is enormous and the time required to achieve new knowledge has often been short. Major disruptions in the short term are sure to occur, but we can be confident that in the long term we can overcome specific pollution problems.

But a larger, more fundamental consequence of energy consumption remains for us to confront. It is well known—but often overlooked—that all energy consumed is eventually degraded to heat and discharged into the environment. Thus all of today's energy consumption (about 72×10^{15} B.t.u.s in the U.S., over 220×10^{15} B.t.u.s in the world) ends up as heat. This heat represents an additional load which the atmosphere must handle and radiate to outer space. In addition, CO_2 and other emissions influence the transmission of radiant energy through the earth's atmosphere. For example, the greenhouse effect from CO_2 in the atmosphere caused by reduced infrared transmission can effectively increase earth's equilibrium temperature.

To place both heat release from energy use and CO_2 from combusting fossil fuels in perspective one needs to consider the total energy received by the earth's atmosphere from the sun—an amount which depends strongly on conditions in the atmosphere itself—the presence or absence of water vapor, CO_2, dust, etc. Our best studies show that with the present albedo of the earth, the energy received by the atmosphere from the sun is approximately 3.75×10^{21} B.t.u./yr. Thus today the ratio of heat from energy consumed to solar energy absorbed is $220 \times 10^{17}/3.75 \times 10^{21}$ or 0.59×10^{-4}—six parts in 100,000, a truly very small factor.

But consider future exponential growth of world population and per capita energy consumption. If some reasonable limits are chosen for world population—such as four times today's (about 20 billion people)—and for per capita energy consumption—such as twice today's consumption in the U.S. (about 7×10^{8} B.t.u./yr.) one can envision annual world energy consumption approaching 1.4×10^{19} B.t.u./yr. This would yield a ratio of heat release from energy consumption to solar energy absorption of $1.4 \times 10^{19}/3.75 \times 10^{21} = 0.37 \times 10^{-2}$—an addition of heat of almost 0.5 per cent, a ratio large enough to be of considerable concern. We have now not even a fanciful conjecture of the total global impact. The matter is complicated by the probability that such large energy consumption would introduce variables which, by affecting the earth's total albedo, would be of equal or greater importance than the heat release due to world energy consumption. In fact, if this consumption comes largely from fossil fuels the CO_2 release into the atmosphere may be more serious in its influence than the heat release. The climatic conditions of the earth are determined by the equilibrium between very large natural processes. With today's knowledge man cannot predict what will disturb this balance.

This postulated level of world energy consumption is 64 times the current figure—a seemingly very large margin of safety. But at the current growth rate of world energy consumption (5.5 per cent annually), the postulated annual level of 1.4×10^{9} B.t.u. would be reached in only 75 years. The period of rapid growth in energy consumption for western society dates from the industrial revolution, beginning approximately 150 years ago; 75 years for developing societies to absorb and use already-developed energy-intensive technology is not impossible or even improbable.

Even today there are significant amounts of heat being discharged to the environment in major urban areas throughout the world. In Manhattan Island, for example, the energy consumption heat release is 6.5 times the average sun's energy; in Moscow, 3.

Granted that the climate in such a small region as Manhattan Island is not determined by local influences; but this magnitude of heat release is bound to create side effects. The heat release from space conditioning and transportation equipment on Manhattan Island on a hot summer day, for example, is surely increasing the energy demand of that equipment itself, and it is making climatic conditions worse for all those in the city. Such regional influences of energy consumption on climate will be much aggravated if demand continues to grow; the result can only be further deteriorating conditions in concentrated urban areas.

Energy Conservation

Our present practices in the consumption of energy are a direct consequence of a long history of abundant, cheap energy. The size and horsepower of our private automobiles, the emphasis on trucks instead of more energy efficient rail and water transport to carry goods, the design, construction, and total space conditions of commercial buildings, the design and construction of residential dwellings, the automation of manufacturing processes, and the growing use of materials whose preparation is energy-intensive—all these are examples how our technological decisions have been made on the assumption of continued abundant, cheap energy.

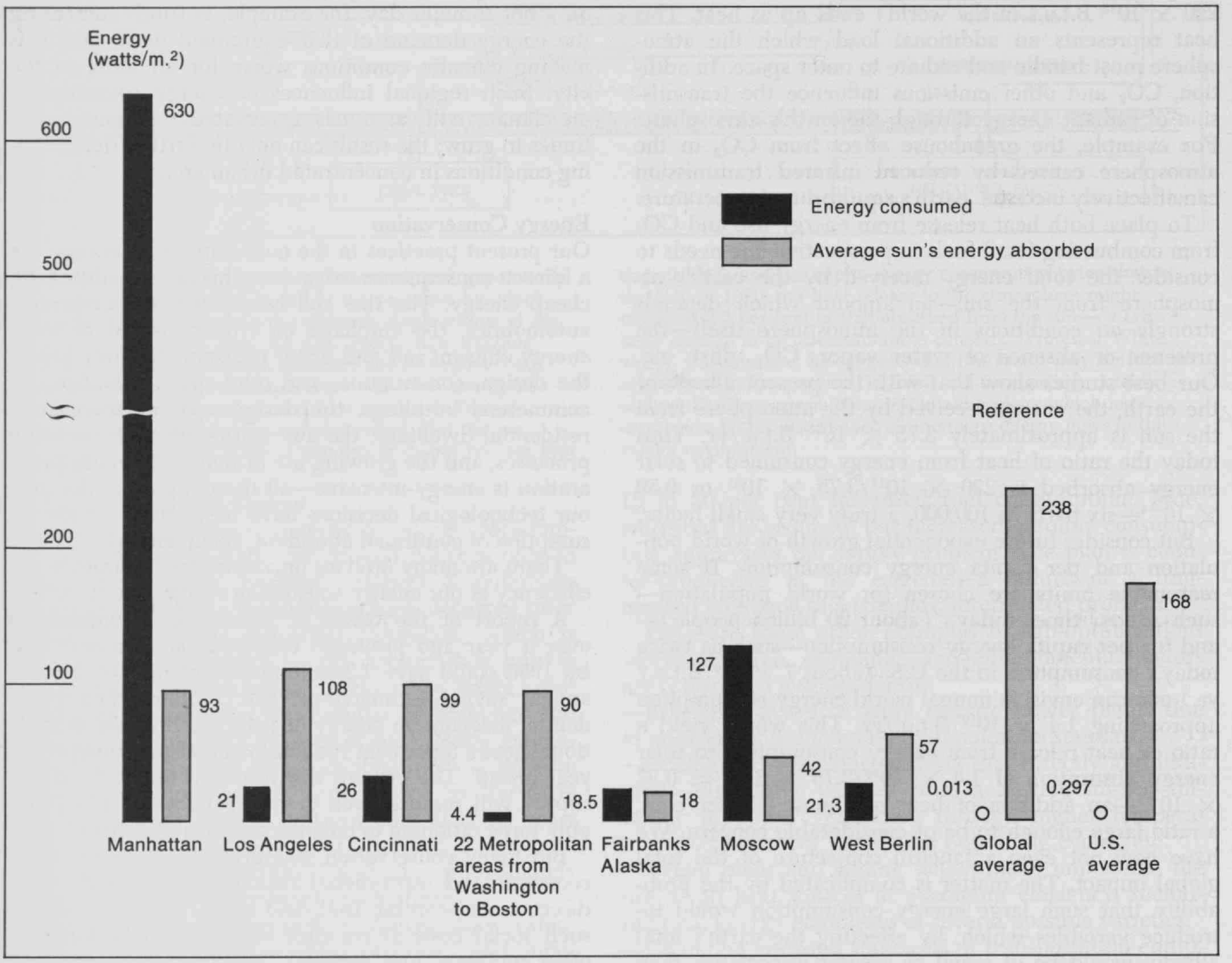
There are many obvious opportunities to improve the efficiency of our energy-consuming equipment.

A report of the Office of Emergency Preparedness over a year ago proposed conservation measures that by 1980 could save 7.3 million bbl. of oil per day, an annual saving estimated at $10.7 billion. The presidential message on energy of June 29, 1973 set as a national goal a 5 per cent reduction in consumption for the year ahead. The current disruption in international oil supply will require even greater reductions and probably force rationing to balance supply and demand.

But many conservation measures are discouraged by economic and institutional structures that weight only direct costs—capital, fuel, and operation—and neglect such social costs as resource depletion, pollution, and other environmental impacts.

Can we in fact continue our historic 15-to-20-year doubling time for the growth of energy consumption? The difficulty of achieving environmentally clean energy processing, converting and consuming equipment; the depletion of domestic, economically producible energy fuels; the growing dependence on new fuel resources from foreign sources; and the enormous implications of growing energy consumption on climate and the quality of our environment—all these concerns shrink in terms of immediate and even longer term importance if energy consumption growth can be reduced so that doubling times are changed to 30 or 40 years.

Though man on the average consumes only one unit of energy for every 16,700 units which are absorbed on earth from the sun, there are "islands" where the heat release from energy consumption is a significant share of the average solar energy input. Energy release on Manhattan Island (the extreme case) is 630 watts/m.², more than six times the sun's average of 93 watts/m.² On a hot summer day, thinks the author, heat release from energy consumption in Manhattan must indeed be "making climatic conditions worse for all those in the city." (Chart: *Man's Impact on Climate,* M.I.T. Press, 1970)



Halving the growth rate in energy consumption would give all segments of our energy system much greater flexibility. Advances in technology could more likely keep ahead of foreseeable and unforeseeable difficulties. Indeed, conservation to reduce the present energy growth rate, while still satisfying the important needs of society, is the most significant step that could be taken today to resolve the "energy crisis" which we foresee for the remainder of this century. New energy supply developments, new conversion technology, and new resource discoveries have relatively far less potential for relief.

Energy conservation in this sense does not mean simple changes in energy-consuming equipment. Nor will research and development in the area of energy and conservation seek great new scientific discoveries; in fact, most of the needed basic technology already exists. Effective conservation demands that all of society's functions that draw directly or indirectly on energy consumption be reconsidered. The large rewards will come from fully exploiting existing technology, from changes in economic balances by market prices or incentives, and from the concerted efforts of an informed and interested consuming public.

Conservation will involve socio-technological problems—issues of market costs and societal goals which are not clearly separable and with which today's economic processes have no clear method for dealing. For example, the very long lifetimes of energy-consuming equipment mean that planning of plant expansion and especially of future research and development must be very forward-looking. The times involved in many instances exceed those which profit-making industries and economy-minded consumers typically consider when estimating the future worth of investments at prevailing interest rates. Another problem, too: some technological advances cannot be captured for profit by a single industry or group of industries, thus yielding no return for money invested. Under these conditions we require the kind of new ideas, research, and societal evaluations which selected industry groups or government have traditionally contributed and which to a large degree only such organizations can finance in the face of uncertainty and the long lead times involved.

Fortunately, government and some industry groups have started to recognize their responsibility. The formation of the Electric Power Research Institute by the electric utility industry is one example.

Defining the "Energy Crisis"

The previous sections of this article have introduced a sequence of dilemmas in what may be described as the energy-environment-economic triangle; together they represent what is popularly called our "energy crisis." These dilemmas arise in the natural development of a growing and healthy economy in the U.S. and other industrialized nations maintained by abundant, cheap energy supplies. Such exponentially growing economies have carried with them exponentially growing energy consumption, and this in turn has produced demands for energy that exceed easily accessible indigenous supplies; thus the industrialized nations are increasingly dependent upon foreign fuels supplied primarily from the natural resource bases of some of the developing countries. The technology to produce energy economically from more inaccessible fuels is still lacking, with the result that for many developed countries domestic energy sources are more costly to exploit than foreign sources. The domestic costs appear to be setting the base price for foreign fuels, and the future seems to hold the high probability of very large transfer payments from industrialized nations to the fuel-rich developing nations.

In fact, the upper bound on such foreign fuel prices seems to be the cost of substitute fuels that are truly available in the marketplace to supply the next marginal unit of fuel demand.

Meanwhile, an awakened population in the developing nations is tracing the path of western industrialized societies. Growing economies in all developing nations are now showing consumption patterns closely analogous to those of the U.S. and other Western countries. This raises the possibility of sustained growth in worldwide energy consumption at a rate even higher than any single industrialized nation has yet experienced. As energy use increases, the volume of waste products from energy production and consumption begins to exceed the ability of natural environmental processes to absorb it without severe degradation. This in turn suggests the large-scale releases of CO_2 from fossil fuel consumption and in addition, of the ultimate pollutant, prime chemical or nuclear energy degraded to heat and injected into the atmosphere. From this source there is the possibility of local climatic disturbances in later decades and worldwide effects which are unknown but potentially disastrous in as short a time as a century.

Each of our dilemmas has at one time or another been identified as "the energy crisis," and in each case approaches have been recommended for a specific solution to each specific problem. But in fact all our problems and dilemmas are actually symptoms of the true crisis of today; that the political and economic processes by which mankind's actions are now controlled are tuned to immediate and short-range influences of the socio-economic marketplace. Criteria for action are based on immediate consequences; the best long-term approach we are now able to justify is a cost-benefit analysis based on interest rates closely pegged to today's cost of investment capital that have been modified to account for uncertainty and risk.

That mankind should view the "energy crisis" so myopically is tragic indeed. We must, of course, continue to undertake short-term fixes as we focus on energy production and consumption issues. But it is imperative that truly long-term, fundamental investigations provide alternative options for society many decades into the future. Society must expend the effort to understand the options and to communicate to responsible leaders a consensus on future decisions. These goals require both basic and applied research coupled with action programs on items such as the following:

—Energy sources which have minimum environmental influences, including but not limited to the fossil and nuclear fuels.

—Fundamental climatic processes, including local and global effects of energy consumption and the thermal balance of the earth in its setting in the universe.

—Adjustments to domestic policy, government actions, and free market practices that more adequately deal with future uncertainty, utilize national resources for the long-term good of society, and comprehend the vast differences in the response times between marketplace economics, technology, development, basic physical research, and the biological and physical processes of our ecosphere.

—International institutional mechanisms that will permit and indeed stimulate effective responses to changing domestic and world needs for energy.

The dilemmas which constitute the "energy crisis" will continue and in fact will inevitably intensify unless ways are found to deal effectively and soon with issues such as those listed above. The end of the "free ride" for mankind in his environment is fast approaching.

David C. White, Ford Professor of Engineering in the M.I.T. Department of Electrical Engineering, was named Director of the Institute's Energy Laboratory upon its formation in 1972. Professor White has published extensively in his fields of research—energy systems analysis, electromechanics, direct energy conversion, and electric power systems; this article is based on a paper presented at the 1972 annual meeting of the American Society of Mechanical Engineers. He studied at Stanford University and has been a member of the M.I.T. faculty since 1952.

America's proven coal reserve amounts to 390 billion tons, and our probable total resource is eight times this figure. Coal is thus by far our largest fossil energy reserve, and technology to resolve the environmental and economic constraints on its use deserves high priority

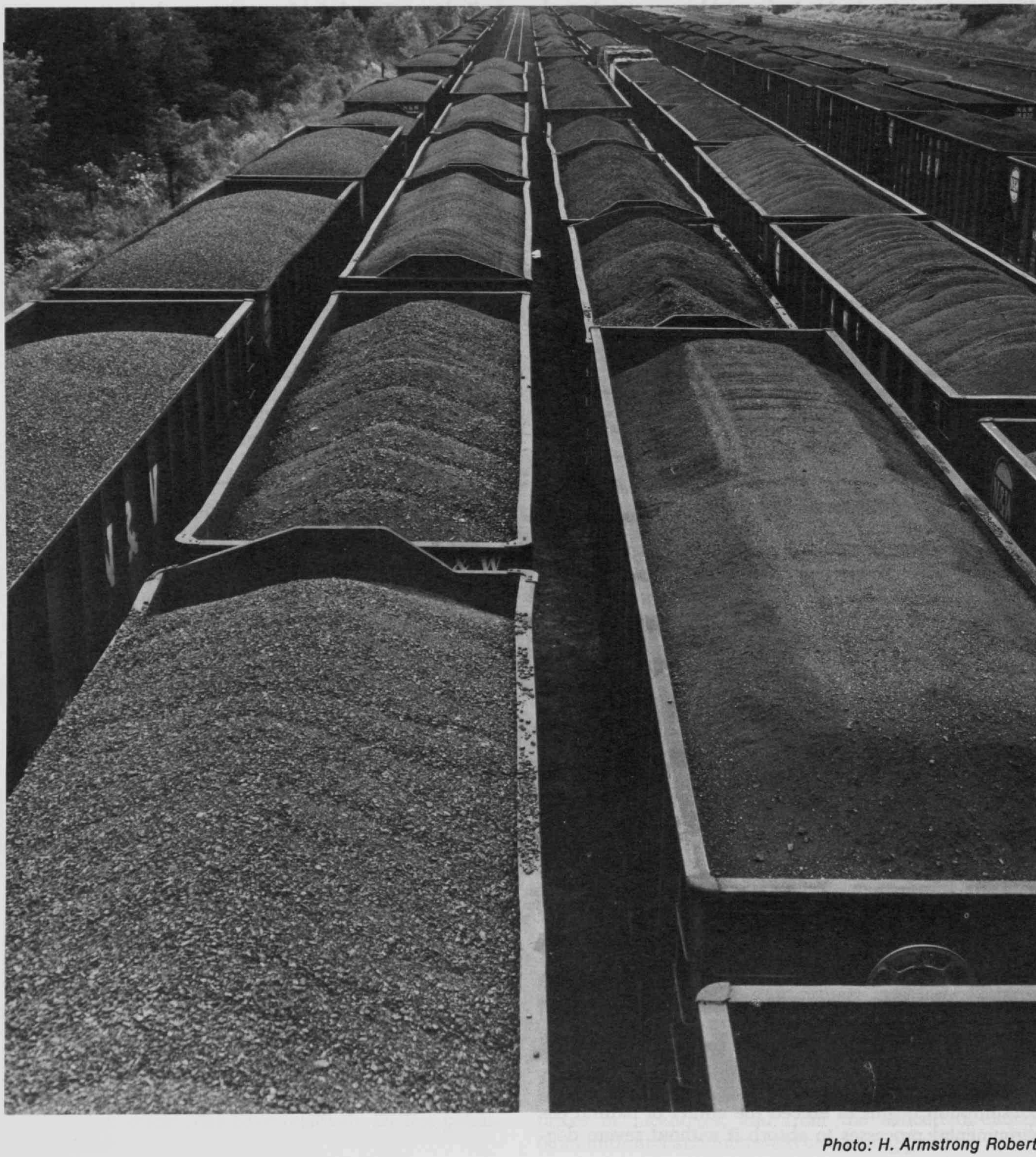


Photo: H. Armstrong Roberts

Edmund A. Nephew
Oak Ridge National Laboratory

The Challenge and Promise of Coal

Coal is by far the most abundant of the fossil fuels, both in the United States and in the world. The original, in-ground coal resource of the United States, as determined from mapping and exploration, is estimated to have been some 1,624 billion (short) tons. This amount includes all bituminous and anthracite coal in seams greater than 14 in., and all sub-bituminous coal and lignite in seams greater than 30 in. found at depths up to 3,000 ft. An additional coal resource of 1,650 billion tons, bringing the total to more than 3.2 trillion tons, is considered probable from presently unexplored and unmapped areas and at greater depths—up to 6,000 ft. Even allowing for past depletion (40 billion tons of cumulative coal production) and for losses incurred during mining (a similar amount), the enormous magnitude of our remaining coal resource is evident when it is compared with the annual production in 1969 of 560.5 million tons.

Our actual coal reserves are much smaller than this total resource estimate, however, because only a fraction of the total resource can be considered minable under present economic conditions and with present technology. Most of the overall coal resource lies either at depths too great, in seams too thin, or at locations too remote from present-day markets to permit economical recovery. Studies by Paul Averitt indicate that the recoverable coal resource in the U.S. under less than 1,000 ft. of overburden amounts to 374 billion tons in seams of intermediate thickness and 406 billion tons in thick seams. Thus, assuming a recovery factor of 50 per cent, only 390 billion tons of the total coal resource can be considered as a proven, identified reserve. This amount represents slightly less than one-eighth of the total probable U.S. coal resource.

In 1968, the total U. S. production of coal was 556 million short tons. At this production rate the remaining proven coal reserves in the United States would suffice for nearly 700 years.

This apparent abundance of coal is illusory for at least two reasons. The annual consumption rate will rise sharply as shortages in the other fuels become more pronounced, as new uses for coal are developed, and as normal industrial growth occurs. And intensive exploitation of the U.S. coal resource may be limited by severe stresses upon the environment which are associated with coal production and consumption.

Technology Turns Mining to the Surface

An intelligent forecaster in the 1940s pondering the distribution of the coal resource as shown in the table on the next page might have concluded logically that future advances in coal mining technology would occur in three principal areas. In order of priority, these advances would have been: the development of techniques yielding a higher percentage coal recovery, the adoption of new methods for economically mining thin seams, and mining at ever greater depths. Progress in each of these areas would result in a higher utilization of the total coal resource, thus expanding the nation's coal reserve.

Coal mining today is far removed from the static, old-fashioned art still envisaged by some people. Both underground and surface mining have been subject to substantial technological change. But the most striking improvements in mining technology over the last three decades have not been in the field of underground coal mining. Instead we have witnessed a continuing increase in coal surface mining, which has more than compensated for a declining production from underground mines. In 1971, for the first time in history, the total coal production from strip and auger (surface) mines surpassed that from deep mines.

The large production of coal by surface mining has resulted primarily from improved, heavy excavating equipment introduced in the 1960s. Mammoth draglines with bucket capacities up to 220 yd.^{3}, power shovels, and bucket-wheel excavators weighing nearly 8,000 tons are now in use. These machines, exploiting economies of scale, have made possible the surface mining of coal at ever greater depths and, at the same time, have nearly doubled the output per man-day from coal stripping operations.

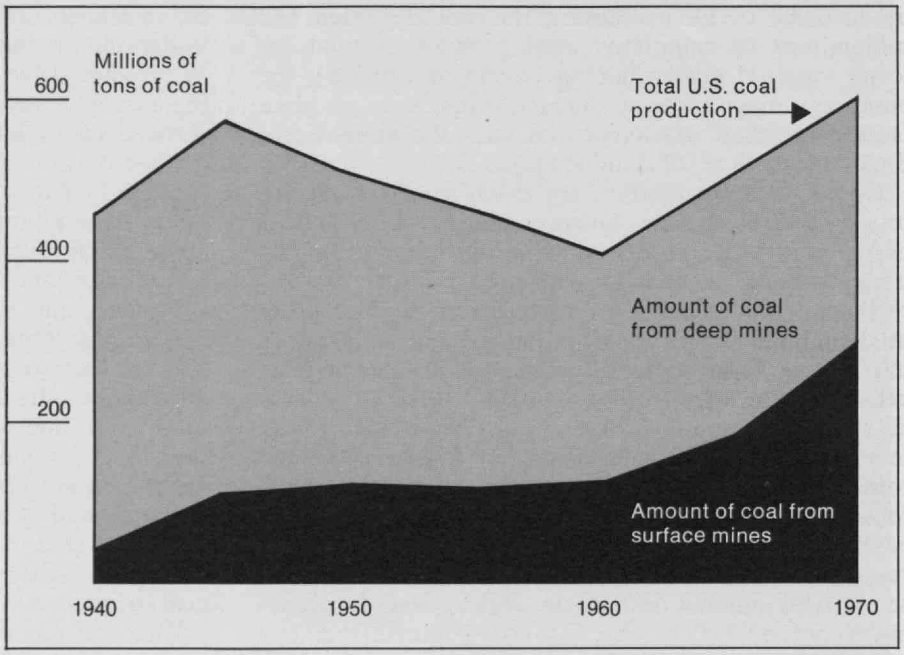
The coal recovery factor for surface mining, except in the case of augering, is much higher than for underground mining, approaching 80 to 90 per cent. In addition, during the process of stripping away the overburden to reach thick coal seams, thinner seams are often encountered and profitably extracted. Indeed, at first glance it appears that coal surface mining fulfills two of the important technological objectives for coal mining described above, and it is on this basis that strip mining has advanced so rapidly in the past three decades.

Yet during the same period, two and possibly three major technological revolutions have swept the underground mining industry, bringing worker productivities there to new highs as well. These changes began in the 1940s when hand cutting and loading were re-

Surface mining must have a small role in the ultimate history of America's recovery of its bountiful coal resources. For less than 10 per cent of the total U.S. coal resource lies within 150 ft. of the surface of the ground—the maximum depth at which surface mining is likely to be practicable with presently foreseeable technology.

Overburden thickness (feet)	Amount of U.S. coal resources (billions of tons) — Coal seam thickness: 14 to 28 in.	28 to 42 in.	Over 42 in.	Total
0 to 100	}Total of surface-minable coal resources{			115
100 to 150				50
Less than 1000	666	374	406	1,446
1000 to 2000	33	73	49	154
2000 to 3000		5	20	25

Coal represents the most abundant fossil fuel resource in the U.S., but its production and use are limited by economic and environmental constraints. Though only a small fraction of all U.S. coal can be reached by surface mining, that method has gained ground rapidly in the past decade as a result of new technological developments. Now similarly major technological changes may be on the horizon for deep mining. (Data: Bituminous Coal Facts—1972)



placed by a fully mechanized procedure for cutting, drilling, and blasting the coal from the seam face. Loading machines were built to gather up the loosened coal and load it into shuttle cars for transportation to the surface. In the 1950s, several of these separate steps were unified into a single operation with the development of the continuous mining machine, which rips coal directly from the seam using a rotating cutter head equipped with replaceable teeth. The same machine transfers the coal to conveyor belts or shuttle cars, eliminating the need for a separate loading operation. Today, more than half of the coal produced in underground mines is extracted and loaded by this method.

A third major advance in underground mining, today still in its infancy, began in the 1960s with introduction of the longwall mining technique. As will be described later in this article, the longwall system, with powered roof supports and partial or full automation of the face equipment, affords the promise of truly exciting increases in productivity—prodigious coal cutting capacity, for example, of as much as 5,000 tons per shift with a 10-man face crew.

The end result of these innovations, both above and beneath the surface, has been to increase the average productivity from all mines from five tons per man-day in the 1940s to 20 tons per man-day in the 1970s. The success of these astonishing strides is best placed in

Though more than 90 per cent of all U.S. coal reserves are inaccessible to strip mining, recent technological advances in the mining industry have almost without exception focussed on surface mining, by which we now obtain more than half the coal we use

perspective by comparing the results with current productivity levels of Western European nations—two to four tons of coal per man-day.

Surface Mining and the Environment

The coal found in the Appalachian mountains was originally deposited in horizontal layers. Over millions of years, erosion and weathering have cut deep valleys into the highland plateau and shaped the landscape we observe today. The coal outcrops thus exposed roughly follow the contour lines as on a topographical map. Stripping in its conventional form proceeds along the coal outcrop, with the overburden material removed from above the coal bed during each cut typically being cast down the hillside or stacked along the outer edge of the bench. The exposed coal is then removed and a second cut is made to uncover more coal. Finally, when the overburden becomes too thick for economical stripping, augers—up to seven feet in diameter—are used to drill horizontally several hundred feet into the coal seam to bring out additional coal.

The mining proceeds along the mountainside using this combination of stripping and augering. Behind is left a steep, nearly vertical highwall on the upslope side, and piles of overburden or spoil material stacked along the outer bench or cast downslope.

In other parts of the U.S., where coal seams are located near the surface under level terrain, strip mining is simpler. An area is cleared of overburden and then of coal, and the overburden from the next adjacent area is moved onto the cleared area. There remains eventually a surface composed of heterogeneous overburden—mostly gravel and small rock—in whatever form was dictated by the machinery from which it was dumped.

The environmental impacts of strip mining are not confined to the directly disturbed areas. Siltation of streams from erosion of spoil and acid water run-off extends the harmful effects of strip-mining far beyond the actual mine site. (Acid water is water containing sulfuric acid produced by weathering of sulfur-bearing minerals.) According to a recent Appalachian Regional Commission study, contamination caused by both deep and surface mining has substantially altered the water quality of some 10,500 miles of streams in Appalachia, and acid drainage seriously pollutes some 5,700 miles of streams. Annual erosion from freshly strip-mined areas in Appalachia is as high as 27,000 tons per square mile, or up to 1,000 times greater than for undisturbed lands. There are many examples of marked decreases in the variety and abundance of aquatic life downstream from strip-mined areas, caused by erosion and acid water drainage which effectively destroyed stream habitats. Landslides, damage to timber, and as-yet-unknown effects such as the spread of heavy metals or carcinogenic materials by leaching of the spoil during rains add to the list of possible off-site damages.

The nature of environmental damage from coal surface mining depends significantly upon the climate and terrain of the mining region. Large-scale surface mining of coal has now begun in the water-poor regions of the West and Southwest, and these operations may pose environmental hazards which we do not yet understand. For example, in the semidesert Southwest, surface mining may bring highly saline material to the surface. The difficulties of establishing new vegetation on this overburden material will be far greater than in the Appalachians. Before the long-range feasibility of surface mining in arid regions can be assessed, revegetation methods effective in regions with low average rainfall must be developed, soil conditions must be investigated, and the groundwater movements must be determined. Although additional research is needed, it is clear that strip mining—whether conducted in Appalachia, in the Southwest, or in harsh northern climates—can seriously affect ecological balance.

Erosion, acid run-off, and ground slides are inevitable consequences of conventional mountain strip mining, with no reclamation. An exhausted, abandoned mine may contribute to stream acidity, sedimentation, and landslides for many years to come. In contrast, a new method of contour strip mining, known as the modified block cut method of mining, avoids many of these adverse effects.

Briefly outlined, the block cut method involves completely mining to their full depth a series of sections of a coal seam. The spoil from the first section of the seam is stored on the downslope side of its bench or off-site if possible. Then this first mined area is available to hold the spoil from sections immediately adjacent on both right and left, and in turn these mined areas are used for storing the spoil from the next sections. Finally, the spoil from the first section is distributed to the last mined sections as mining of the property is completed.

This block cut system reduces the area of disrupted land and improves the potential for economic land rehabilitation by eliminating the need for double handling of most of the spoil.

How to Restore Strip-Mined Land

Much of the environmental damage from strip mining can be reversed, though the cost of land restoration varies greatly, depending on how the mining was conducted and on the degree of restoration required.

The method used for removal and replacement of the overburden is of crucial importance both to the economics of coal production and to successful land reclamation. Economic coal recovery is possible only if the spoil is handled minimally, with the overburden placed when first removed at or near its final resting place. At the same time, successful reclamation requires that the overburden be placed in a stable condition and selectively layer-sequenced to provide the best soil materials on top, with heavy rocks and toxic substances deeply buried.

In order of increasing costs and quality of reclamation, the alternatives may be described as follows:

—*Basic reclamation* consists simply of spoil stabilization and the prevention of offsite damage. To achieve this minimum level of reclamation, spoil material must be placed during mining operations in stable configurations which reduce the probability of landslides, with the best soil materials on top and toxic substances, including acid-forming materials, buried deeply. Access roads must be designed and maintained to prevent erosion. Following mining, water catch basins must be built to prevent stream siltation and grading, ditching and revegetation completed to reduce erosion.

—*Partial reclamation*—involving greater effort—is required if the reclaimed land is to become productive in a reasonable period after mining. The land must be returned to a topography suitable for the intended future uses. The spoil bank need not be returned to the approximate original contour; it can instead, for example, be graded to form "terraces" of various shapes suitable for grazing cattle and other uses; high walls need be only partially toppled to improve safety and accessibility. The spoil must be handled with care during mining so that the original sequence of strata—including upper and lower leach layers—in the overburden is preserved. The original topsoil or perhaps a superior alternative material must be put in place. Following mining the steps listed above must be taken, and then the land must be managed for a period of several years to restore the nutrient and humus levels of the soil.

—*Full reclamation* includes all of these, plus detailed grading of the land approximately to its original contours and revegetation with native plant species—or with foreign species which will better respond to the new conditions but which are ecologically compatible with local flora.

No sensible discussion of the costs of land restoration is possible unless the reclamation objectives are clearly specified.

The amount of spoil that has to be moved during reclamation is the principal factor in costs. Return-to-contour typically requires movement of 75 per cent of the total spoil material, while the various terrace backfills require movement of only 25 to 40 per cent of the total spoil. Other cost variables include the average haul distance involved and the type of overburden. In all cases the cost of backfilling and revegetation is much lower if the work is performed at the time of stripping.

Recent estimates (1972) of the Appalachian Regional Commission indicate backfilling and grading costs of \$1,000/acre for return-to-contour backfilling and \$600/acre for terraces. Covering the graded spoil with topsoil may cost as much as \$0.50/yd.^{3}, or up to \$2,500/acre. Revegetation costs, including soil treatment measures such as mulching, liming, fertilizing, and seeding, range from \$100 to \$500/acre. Thus the total cost of full reclamation—for all of these activities—appears to be of the order of \$1,500 to \$4,000/acre.

This estimate agrees well with reported foreign experience and is much higher than the costs of \$200 to \$300/acre sometimes quoted in the coal mining industry. Clearly, industry spokesmen are speaking of a lower quality of land reclamation.

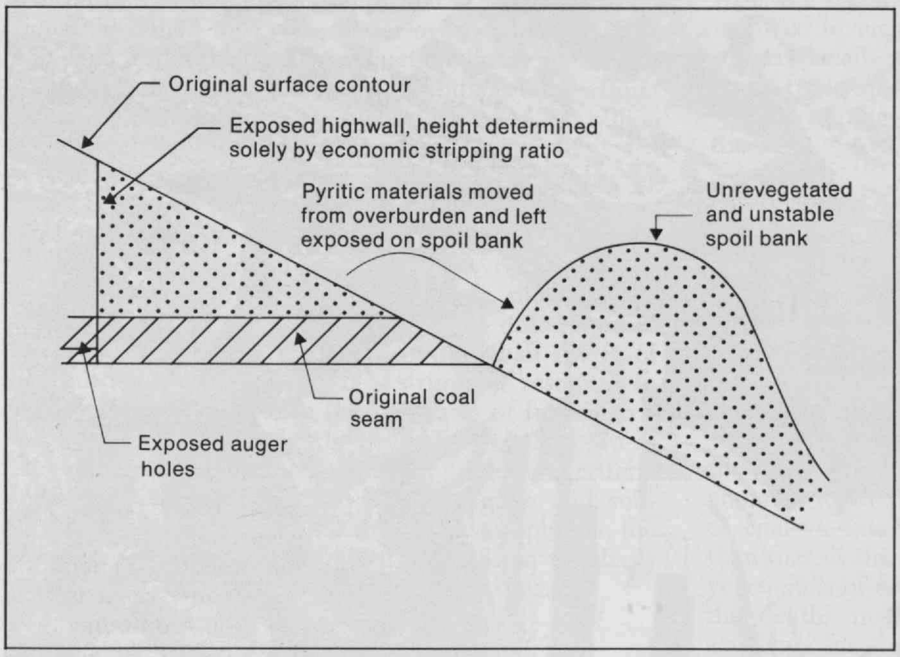
Prior to the early 1960s, even basic reclamation, as defined above, was uncommon in the mountainous coalfields of Appalachia. The resulting widespread environmental damage has since prompted most states to require at least basic—and in some cases more complete—reclamation. Full land reclamation is not commonly practiced in the United States, although it has been applied extensively in some countries of Europe, notably in the United Kingdom and the Federal Republic of Germany. In the U.S., Pennsylvania is especially noted for stringent reclamation requirements; its law specifies some of the features of full reclamation described above.

Although judgments vary, most people would agree that basic reclamation is essential. Large segments of the general public and the mining industry would probably consider partial reclamation to be sufficient. Full reclamation may be needed in some cases, to prevent the loss of valuable land-use options, such as the development of scenic, mountainous regions for recreational purposes.

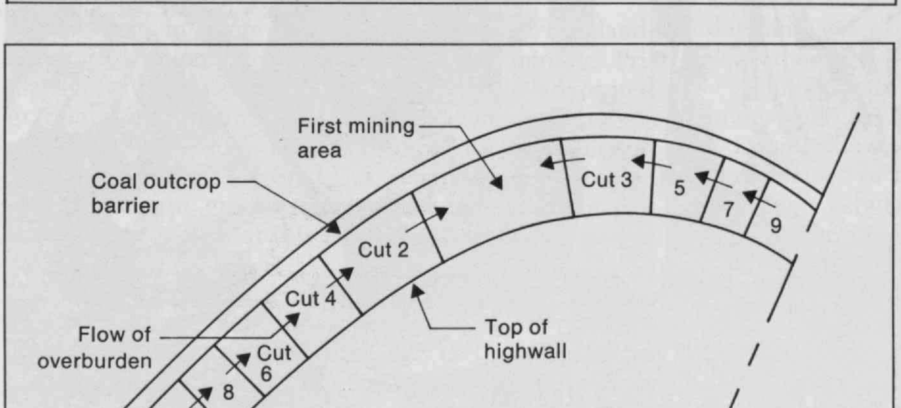
Stripping: Large and Growing Larger

The lands already affected by contour and area strip mining in the United States are enormous in extent. The production of surface-mined coal in the United States has already resulted in some 3,000 square miles of disturbed land. At present coal stripping rates, more than 100 square miles of new land are being stripped annually—and surface mining is increasing because of its high profitability.

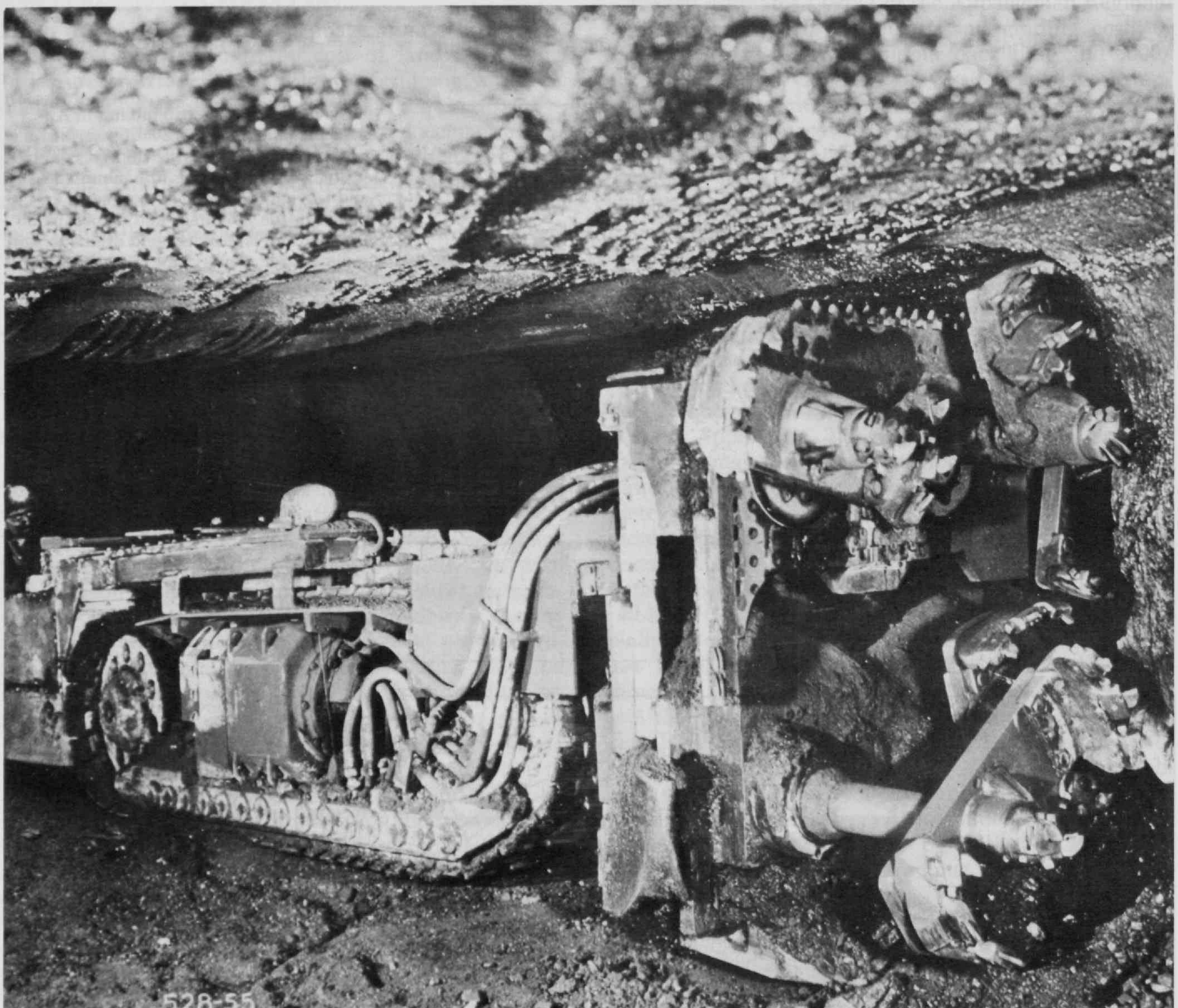
As a result, extensive tracts of unrestored land have accumulated and whole watersheds have suffered extensive damage. Thus, the nation is presently faced with



In its crudest form, strip mining in Appalachia consists of excavating surface material to the depth of the desired coal by pushing the spoil down the mountain—and leaving it there. There remains an ugly gouge in the mountain and a spoil bank contributing landslides, acid drainage, and sediment for many years to come. Fortunately, writes the author, this type of mining "has virtually disappeared" from Appalachia today.



This plan view shows the modified block-and-cut method of strip mining which can provide high quality land reclamation after the coal is removed. The overburden from the first mining area of a property is removed and then the coal is cut away. Then mining begins in cuts 2 and 3, with the overburden placed in roughly the original sequence and contour in the first mined area. Mining then proceeds through additional cuts, with the overburden in each case moved in the direction of the arrows. Finally, the spoil from the first mining area is returned to cover the scars of the last areas mined—cuts 9 and 10 in the diagram at the left.



This Jeffrey "Colmol" is one example of the new machines by which underground coal mining is gradually being made more efficient. But longwall techniques, a larger departure from conventional mining which eliminate entirely the inefficiencies of room-and-pillar mines, hold far more long-range promise. (Photo: Ewing Galloway)

backlog of environmental damage from coal mining in the form of unreclaimed land and degraded river systems. This past damage must be repaired and regulations must be implemented to curb further destructive mining practices. There is a growing agreement that federal legislation is needed to set surface mining and reclamation standards and to require land restoration as an integral part of the mining cycle.

Two independent estimates of the remaining strippable coal resource in the United States have recently been made. The first, by Averitt, rests primarily upon relatively comprehensive data on the coal resource located under less than 100 feet of overburden in ten selected states. From these data, obtained from mapping, exploration, and other sources, extrapolations are made for the remaining states, taking into account their geological characteristics, known total coal resource, and other factors. The conclusion is that before mining began strippable coal resources of the U.S. were 165 billion tons; of this some 115 billion tons were under overburden with depths up to 100 ft., and an additional 50 billion tons were under overburden of 100 to 150 feet. Production and production losses in surface mining have to date been some 5.5 billion tons; assuming an 80 per cent recovery factor, a total of 128 billion tons of recoverable strip coal remains.

A more recent study of strippable coal resources by the U.S. Bureau of Mines yields a slightly lower figure. This study uses two criteria for maximum overburden thickness and minimum seam thickness. For coal fields reasonably close to high-demand markets, such as those of Appalachia or the midwest and Gulf states, coal in seams of 29 in. or more covered by less than 120 ft. of overburden is considered to be a strippable resource. In the western states, coal in thicker seams of from 4 to 5 ft. and at overburden depths generally less than 150 ft. is considered strippable. (Slightly different criteria were used to define surface-minable lignite and subbituminous coal.) After allowing for past depletion, the remaining strippable resource in the U.S. on this basis was found to be approximately 118 billion tons.

Deep Mines: Hostile and Hazardous

Mining coal in deep mines avoids much of the landscape disruption accompanying surface mining. Primarily for this reason, many people have advocated gradually eliminating all coal surface mining and expanding the capacity of underground mines. Although the distribution of the total U.S. coal resource will some day necessitate greater reliance on deep mining, we should not forget that this form of mining also presents serious problems.

Under the best of circumstances, the underground coal mine represents an extremely hostile and hazardous environment for the miner; this fact is reflected in the much higher injury and death rates experienced in underground mining. Present-day underground mining also suffers from low productivity and low resource utilization, as compared to surface mining. Furthermore, although they are not as visually dramatic as in strip mining, the environmental impacts from deep mining—acid mine drainage, land surface subsidence, gob disposal, and mine and waste heap fires—are far from trivial. Indeed, studies have shown that the drainage of acidic waters from underground mines presently poses a greater problem than acid mine drainage from surface mines.

Technological advances are needed in each of these areas if a shift toward deep mining is to occur. Otherwise, the social, economic and environmental trade-offs involved in such a shift may be unacceptable. We now discuss briefly the nature and magnitude of some of these trade-off problems and the prospects of a new form of mining—the longwall system—for ameliorating them.

Safety: Room for Improvement

The human costs of moving from surface to underground mining take the form of higher injury and death rates and of greater occupational hazards in general. In 1971, 86 per cent of all coal mining fatalities occurred in underground mines. In the same year, only half of the total coal production came from deep mines. Over the seven-year period 1965 to 1972, 1,412 lives were lost in the underground coal mining industry in the production of 2,336 billion tons of coal. This amounts to an average of 0.606 deaths per million tons of coal—a fatality rate more than five times greater than that of the coal surface mining industry. In recent years, falls-of-roof have accounted for 40 per cent of the deaths in underground mines and coal haulage accidents for about 20 per cent. Annual fatalities from dust and gas explosions fluctuate greatly, but over the years there has been a declining trend.

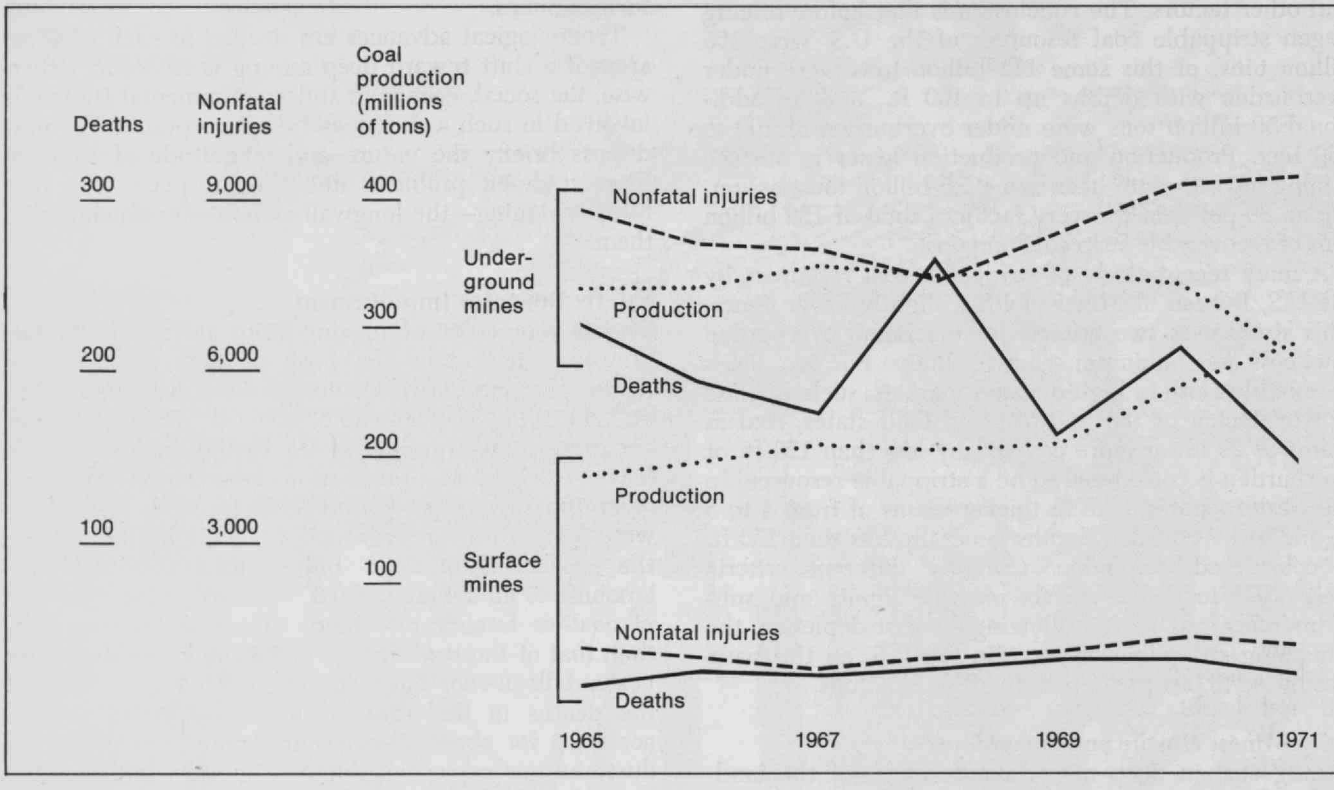
A similar safety disparity between surface and deep mines holds for non-fatal injuries as well.

During the time period from 1968 to 1971, the safety performance in deep mining of the nation's top ten coal producers ranged from 0.28 to 1.52 deaths per million man-hours. The differences are even more marked for the category of non-fatal injuries—2.72 to 72.13 injuries per million man-hours. Since the passage of the Coal Mine Health and Safety Act of 1969, most companies have greatly strengthened their safety programs, and this increased emphasis on safety may bring significant improvements in fatality and injury rates. Indeed, the wide range of safety performances cited above makes it clear that—even without a technological breakthrough—much can be done to narrow the safety gap existing between deep and surface mining.

Resource Utilization and Productivity

Underground mining is generally more wasteful of the coal resource than surface mining. Room-and-pillar mining by conventional methods may leave as much as

Underground coal mining has a poor record—an inefficient, unproductive, dangerous industry. But prospects are bright for significant progress through new technology—and thus for the resurgence of underground coal mining



The safety record of surface mining—in terms of both deaths and nonfatal injuries per ton of coal mined—is spectacularly better than deep mining, which provides at best a hostile, hazardous environment for the miner. The record of underground mines will improve as the impact of the Coal Mine Health and Safety Act of 1969 continues to increase, but the requirements of this Act may also increase the cost of underground mining enough so that surface mining—at least in the next decade—becomes the dominant method of obtaining coal. (Data: Bituminous Coal Facts—1972)

50 per cent of the coal behind. Although the recovery factor for continuous mining, employing pillar retreat sections, is much higher, the average national recovery factor for underground coal mines is still only 57 per cent. The remaining 43 per cent of the original coal resource is wasted, left in the mine and rendered unfit for future recovery. This loss of reserves represents a significant disadvantage of underground coal mining. In contrast, the recovery factor for surface mining ranges from nearly 100 per cent in open-pit mines to 80 per cent for area and contour stripping and to about 50 per cent for augering.

The productivity of old-fashioned, room-and-pillar underground mines using hand tools ranged from about 2 to 5 tons/man-day. With the advent of mechanized, conventional mining, productivity levels of 10 tons/man-day were obtained. Finally, the introduction of the continuous miner in the 1950s has provided another substantial increase in productivity—to 15 tons/man-day. But the current productivity of surface mining is much higher: 35 tons/man-day in area and contour stripping, 35 to 45 tons/man-day in augering, and up to 80 tons/man-day in open-pit mines. New technological advances are needed to overcome the present higher production costs of deep mines.

Modern Longwall Mining

One such technological advance—longwall mining—may be a significant new development. Although longwall mining, involving the use of stone packs and manually moved roof supports, was once widely employed in the United States, productivity was extremely low

and it could not compete successfully with other mining systems. By necessity, however, the development of longwall mining to meet the more adverse conditions of mining at great depths continued in Europe, where coal reserves under shallow cover have long been exhausted. Gradually, research in rock mechanics and other areas led to a better understanding of the behavior of supports, the structural properties of strata, and roof movement. These theoretical advances were of vital importance, since the success of modern longwall mining depends greatly upon the development of an effective roof control system.

In parallel to these developments after World War II came some major technological achievements which made possible the mechanization of longwall mining: a flexible armored face conveyor capable of being moved forward without disassembly, efficient plows and shearers to ride on rails mounted on the armored flexible conveyor, and self-advancing hydraulic roof supports.

In the longwall system, coal is mined from panels which are established by driving access entries along both sides of the panel. The panels, from 300 to 800 ft. wide and 1,500 to 5,000 ft. long, are connected laterally by the longwall face which contains the shearer, the armored flexible conveyor, and the row of side-by-side hydraulic roof support units. The shearer travels back and forth along the face, biting several feet into the coal; the coal thus cut falls to the conveyor and is carried away. When the cutting machine reaches an access entry, the cutting edge is advanced and process continues, the whole machine returning toward the opposite access.

Following the traverse of the cutting machine, roof support units are moved forward automatically. Each of these consist of four to six hydraulic jacks mounted upon a single base plate; the jacks act to support the roof, each providing a force of from 30 to 175 tons. When the roof support units are to advance with the shearer and conveyor, each unit in turn is decompressed, moved forward, and reactivated. The roof behind is left to collapse. The main roof should fall regularly and predictably, some optimal distance behind the retreating longwall face.

The longwall system of mining offers important advantages which make it highly attractive. These include high productivity, high resource recovery, and improved mine safety conditions. The face equipment can be operated by a small crew of from eight to ten men, and production of up to several thousand tons of coal per day can be achieved. No coal support pillars are left behind, and the operating crew at the face is protected by the mechanical roof support units. Effective ventilation is simpler and easier to provide, reducing the likelihood of gas and dust explosions. All of these features make longwall mining very attractive indeed—if only it could be applied universally.

Unfortunately, at its present stage of development longwall mining is not universally applicable, and many experts in the mining industry believe that it can be employed successfully only in a limited range of stratigraphic conditions. If this is true, longwall mining, though continuing to gain ground, will probably not become the predominant form of underground mining in this country. On the other hand, additional research and development is required before the system can reach its optimum potential. Automation of the face equipment, development of improved haulage techniques, studies of inducing roof collapse, and the development of rapid driving machines are but a few of the challenges ahead.

The distribution of U.S. coal resources appears to be such that the vast bulk of the nation's coal will remain forever inaccessible to recovery by surface mining methods. This means that we must improve existing underground mining techniques and develop new ones if we are to utilize our rich endowment of coal. Long-run considerations point to the inevitable resurgence of underground coal mining, and the prospects for significant progress in the technology of underground mining appear bright. A vigorous research effort is needed to allow deep mining to reassume its proper role in coal production. Automation of face equipment, improved haulage techniques, hydraulic coal cutting, controlled mine atmospheres, and computer monitoring of mine environments to sense and eliminate hazardous working conditions are examples of exciting research that could revitalize the underground mining industry.

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Assuming successful development and exploitation, a $25 billion solar energy industry might provide 25 per cent of all U.S. energy needs by early in the 21st century

Solar Energy: Its Time Is Near

Outside of the earth's atmosphere the sun provides energy at the rate of about 1,400 watts/m.^{2} (4,730 B.t.u./m.^{2}/hr.) normal to the sun. By the time sunlight reaches the earth's surface, atmospheric attenuation, clouds, and earth shadowing have taken their toll; the average of solar energy falling on a horizontal surface in southern New England, taken over a long time period, is about 160 watts/m.^{2}. If the solar energy density is to be measured on a platform which is movable so that it may be maintained constantly normal to the sun, this annual average may be improved by a factor of nearly two—to almost 300 watts/m.^{2} in the case of Southern New England.

Such energy densities are quite low, and this is essentially why solar energy has to date played a negligibly small role in the U.S. However, assuming 30 per cent efficiency, the total present *electric* power demand of the U.S. could be supplied with solar energy plants having a total area of about 2,000 km.^{2}. This is about 0.03 per cent of the U.S. land area devoted to farming and about 2 per cent of the land area devoted to roads; and it is about equal to the roof area of all the buildings in the U.S.

But such statements do not comprehend the very considerable hurdles which stand between this apparently bountiful energy supply and its collection, storage, and use.

There has been extensive development of fixed-orientation, low-temperature collectors for building heating and hot water heating, and some systems are now in use. These collectors are usually faced south at inclinations of 45° to 60° above horizontal, with one or two layers of glass or plastic used to reduce convection and radiation losses. Transmission losses through these windows are commonly of the order of 15 to 20 per cent.

Of the solar energy passing through the windows, 80 to 95 per cent can be absorbed with simple black coatings. Thus, between 70 and 80 per cent of the incident radiation can be collected.

Losses inside the collector are a function of working temperature and occur by reradiation, convection, and conduction. Convection and conduction losses can be made negligible through good design. The reradiation losses are determined by the infrared emissivity of the absorbing surface and the infrared transmission of the windows. Absorbing surfaces with effective infrared emissivities as low as 0.15 are not difficult to achieve. (An emissivity of 0.15 means that the surface will radiate 15 per cent of the infrared energy that would be radiated by a perfect black body of equal area.) The usable heat is usually gathered from the absorbing surface either by water flowing through tubes attached to the surface or by air flowing over the surface itself.

Assuming 75 per cent absorption and an emissivity of 0.15, net collection efficiencies of between 50 and 75 per cent can be proposed, depending on the outlet temperature—the higher the temperature required, the lower the efficiency.

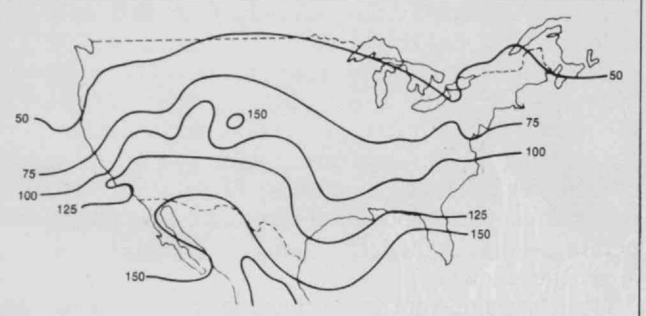
Heat storage for house heating has been accomplished by means of water tanks, bins of rocks, or in hydrated chemicals such as sodium sulfate, whose solid-liquid phase change adds to the heat energy which can be stored.

Assuming a 40° C. temperature change—typical of that required in building and hot water heating applications—water will store 1.6×10^8 joules/m.^{3}; sodium sulfate 3.5×10^8 joules/m^3. Analysis of these figures demonstrates that to achieve the large heat storage required for domestic space heating applications—to provide heat through the night and in bad weather—requires substantial volumes of storage. One to a few days' heat storage is typically used in a solar-heated house, with auxiliary heating sources added to provide heat during extended cloudy periods.

While the temperatures achieved in such low-temperature collector systems as those described above are adequate for heating buildings and water, they are insufficient for high-efficiency production of electricity or artificial fuels by thermal processes; for these applications high-temperature collectors are required. The achievement of high temperatures depends chiefly on concentrating the solar energy from a relatively large area into a small collector, from which it is carried to storage. Conduction and conversion losses can be made small in high-temperature solar collectors by good design, including, if necessary, the use of vacuum insulation around the heat absorber. Indeed, such solar energy concentrators can be very efficient; used in research, they now yield the highest temperatures available in small furnaces for many applications.

The differences between unfocussed and focussed collectors are striking: unfocussed collectors typically have ratios of concentration to emissivity of 10.0 and are limited to output temperatures of 150° C or less; ratios of 300 and temperatures of 600° C. are typical of one-axis-steerable concentrators, and ratios of 10,000 and temperatures of 4,000°C are typical of two-axis-

The total present demand for electric power in the U.S. could be supplied—assuming 30 per cent efficiency of collection—by solar energy falling on 0.03 per cent of the nation's land area, or on the roofs of every building in the country



Collector orientation	Solar energy flux density (watts/m.^{2}) Annual average	December average
Fixed—horizontal	180	67
Fixed—facing south 45° above horizontal	234	127
One-axis steerable in elevation	240	130
Two-axis steerable	335	180

In the northern hemisphere the test of solar energy systems comes in the winter, when energy inputs from the sun reach their minimum. The map shows the average solar energy incidence in the U.S. in December in watts/m.^{2}, the table shows solar energy densities, also in watts/m.^{2}, on collectors with different orientations in an average location in the U.S. in December. To obtain B.t.u./hr. from the figures given, multiply by 3.41.

steerable concentrators. These figures suggest that reasonable efficiencies and temperatures can be obtained with a one-axis concentrator, such as shown in the accompanying illustration.

Solar energy can also be utilized through its conversion into combustible fuels by photosynthesis in trees, plants, and algae. Conversion efficiencies have been estimated to be in the range of 0.3 to 3 per cent depending on the vegetation used. It is possible to imagine an energy system built on this conversion: plants grown with sunshine used to fuel furnaces or boilers, for example. Because of the low collection efficiencies, rather large land areas are required to supply significant amounts of energy.

To supply the total current U.S. energy needs at 3 per cent efficiency would require a land area of about 350,000 km.^{2}, about 3 per cent of the total U.S. land area. Soil depletion and the handling of waste products from the combustion of such fuels are likely to be significant problems for large-scale energy systems which may be conceived to utilize solar energy in this way. However, an interesting variation of this plan is that of utilizing waste from forestry operations and municipal trash collections as a fuel to produce power and/or a synthetic fuel such as methanol. For instance, it is estimated that waste from current forestry operations could provide 10 to 20 per cent of U.S. energy needs projected for 1975.

Photovoltaic conversion of solar energy to electricity using silicon solar cells—direct sunlight striking the cells generates current in an n-p junction in the silicon material—has been widely employed on spacecraft. Typical efficiencies are of the order of 10 per cent, and costs for space-qualified systems can be as much as $1 million per kilowatt. Relatively modest efforts have gone into improving efficiency, and these have yielded silicon and gallium arsenide devices with efficiencies of over 16 per cent. Efficiencies of 20 per cent are believed to be achievable, compared with a maximum theoretical efficiency for simple photovoltaic converters of about 35 per cent.

High cost is as much a problem as low efficiency: arrays of currently available silicon cells (with 10 per cent efficiency) cost about $100,000 per kilowatt of peak capacity when engineered for ground installations without solar concentration. Several efforts are under way to reduce the costs of energy from solar cells of this type. Polycrystalline cells would have lower efficiencies than the single-crystal cells now in use in spacecraft, but they should be much less expensive. Use of solar concentrators with special cells designed for high solar intensities would also increase energy output; a system using a one-axis concentrator would require about 1/50 of the area of a non-concentrating system to supply a given amount of energy. If these cells with a concentrator could be provided at the same costs as today's silicon cells, the cost per peak kilowatt might be reduced by 50-fold—to the order of $2,000.

Given these various alternatives for collecting solar energy at various temperatures and efficiencies, what systems can we envision within the realm of engineering feasibility which will utilize solar energy at capital and operating costs which are reasonable relative to those of other energy systems? Three types of systems for three different applications have been proposed:

The University of Delaware's new "Solar ONE" is the first solar house designed to convert sunlight into both electricity and heat. Solar cells in the collector will convert some 5 per cent of the incident solar energy into electricity and 45 per cent into heat (total, 50 per cent efficiency), and the system is expected to provide up to 80 per cent of the total energy demand of the house.

domestic space and water heating systems, total energy systems for commercial and industrial buildings, and large-scale solar electric power generation.

Solar Houses: The First Chance for Reality

A number of experimental solar house-heating systems have been built and there has been substantial production of solar hot water heaters.

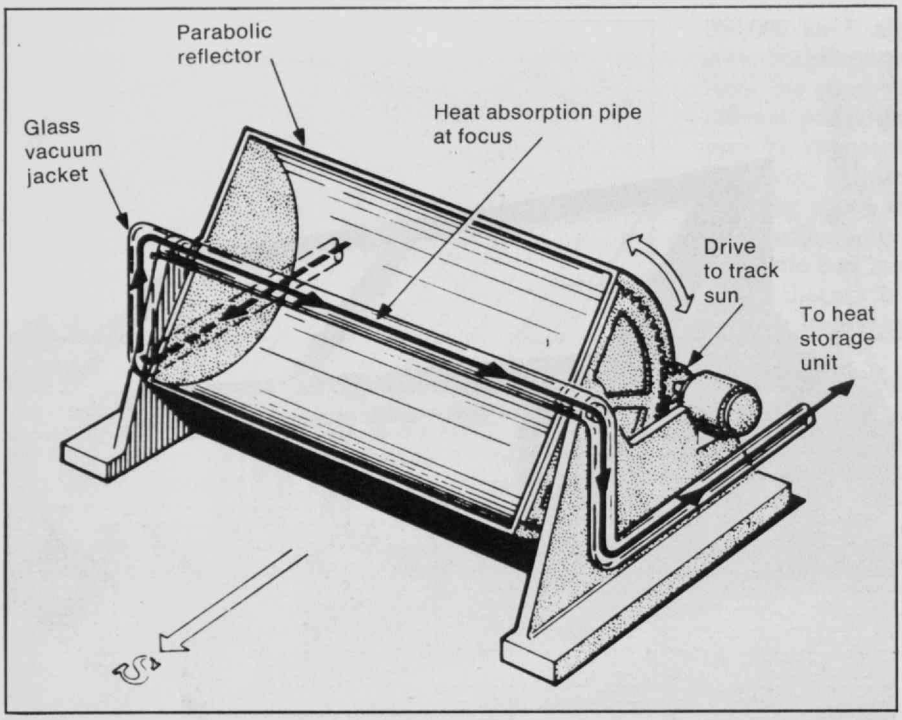
A typical house of 1,500 ft.^{2} area requires of the order of 0.7×10^9 joules/day for space heating during December in mid-U.S. locations (40-degree-day). Hot water heating typically might require another 0.1×10^9 joules/day. In central U.S. locations a fixed 45° collector can be expected to receive an average of about 127 watts/m.^{2} in December, of which perhaps 60 per cent can be retained; thus 0.0066×10^9 joules/m.^{2} could be collected in an average 24-hour period. To provide the needed 0.80×10^9 joules/day for space and water heating would require the heat from approximately 120 m.^{2} (1300 ft.^{2}) of collector area. This could be provided by using somewhat more than half the roof area of a single-floor house or slightly more than the roof area of a two-story house.

Four days of heat storage would require 20 m.^{3} (5,000 gal.) of water (or 64 m.^{3} of rock) heated to 65°C. Smaller storage systems could be used if auxiliary heating were provided for cloudy days.

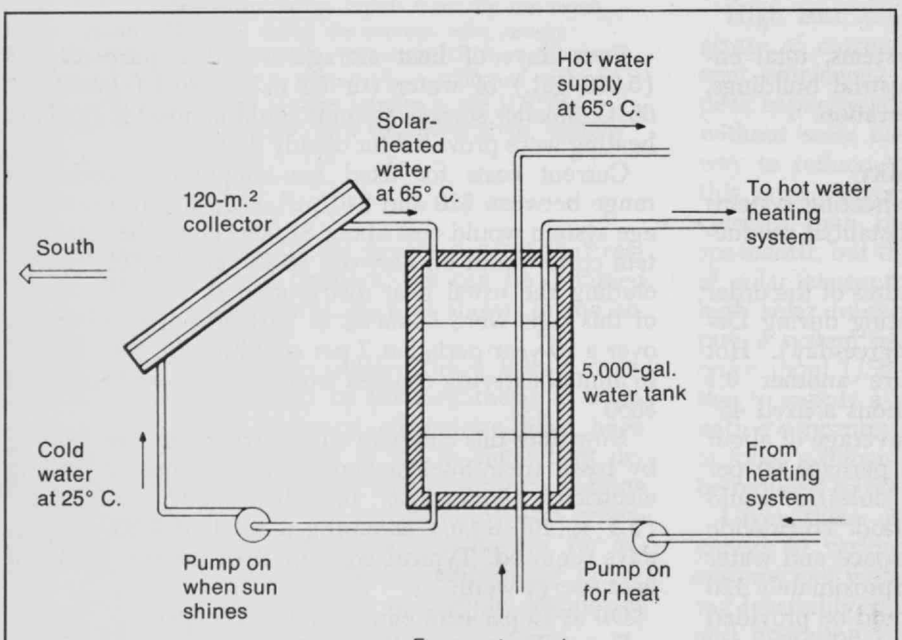
Current costs for fixed low-temperature collectors range between \$20 and \$40/m.^{2}. A 5,000-gal. heat storage system would cost about \$1,000. Thus, the total system costs would be between \$3,500 and \$6,000, not including the usual heat distribution system. If systems of this type were financed as part of house mortgages over a 20-year period at 7 per cent interest, the increase in annual carrying charges would be between \$300 and \$550.

How does this compare with current costs for heating by fossil fuel? Such a house requires fuel or heating electricity equivalent to about 10^{11} joules/year (9.5×10^7 B.t.u.) assuming a total of 5,000-degree-days required. Typical costs in 1972 for 10^{11} joules of heat energy were:

Oil at 75 per cent efficiency (@ 22¢/gal.)	\$280
Gas at 75 per cent efficiency (@ 23¢/100 ft.^{3})	\$275
Electricity at 100 per cent efficiency (@ 1.8¢/K.w.h.)	\$500



When a simple flat-plate fixed collector provides insufficient efficiency and output temperature, a one-axis concentrator is usually proposed for higher efficiency and temperatures at modest cost. This design incorporates a clockwork drive to track the sun and a vacuum-jacketed pipe at the focus of the reflector through which dry nitrogen is circulated to collect heat at 550° C.



The simplest solar energy systems are those designed for domestic space and hot water heating. In such systems, an inclined, southerly-facing flat collector is typically coupled with a heat storage system from which heat can be drawn when required. This diagram shows a combination system which provides domestic hot water at 65° C. and hot water, as well, for space heating.

This computation suggests that solar heating systems are competitive with electric heating today in mid-U.S. locations. Should fuel prices rise significantly faster than the costs of constructing solar heating systems in the future, solar heating could become competitive with gas and oil at some future time.

Total-Energy Systems for the Industrial Park

Most shopping centers and industrial plants now being built consist of one- or two-story buildings in suburban locations. Such facilities require large amounts of energy for heating, cooling, lighting and operations.

A number of such buildings have recently been constructed with gas- or oil-fueled total-energy systems. In such a system electricity is generated by diesel- or gas-turbine-powered generator units. The waste heat from the engines is used for heating in winter and cooling (by means of absorption air conditioners) in summer. Such systems have the advantage over central power systems of recovering the waste heat from the electric generating process.

A similar arrangement using solar energy can be proposed. Parabolic concentrators could provide 550° steam for a turbine-alternator plant whose waste heat was used for heating or cooling, depending on the season.

Approximately 5,000 m.^{2} of one-axis-steerable collectors can be mounted on the roof of a plant occupying 10,000 m.^{2}. About 70 per cent absorption efficiency can be achieved with an outlet temperature of 550° C; thus the heat collected per day will be about 7×10^{10} joules averaged over the year. In order to average out summer to winter solar energy variations, the order of 100 days of heat storage are required. A storage capacity of 7×10^{12} joules can be obtained with 10,000 m.^{3} of insulated rock heated to 550° C. and located along one side of the building. With a thermal electric plant operating at 40 per cent efficiency (which is typical of modern steam generating plants) for perhaps 12 hrs. out of each 24 that the building is in use, an electric power output of about 670 kw. can be delivered. In addition, an average of 500 kw. of low-temperature waste heat would be available over the full 24-hour period for heating or cooling.

No such system has ever been built on such a scale, so the costs are very difficult to predict. Here is a very rough estimate:

Collector: 5,000 m.^{2} @ \$100	\$500,000
Storage: 6,000 m.^{3} @ \$20	\$120,000
1000-kw. steam turbine-alternator	100,000
	\$720,000

The retail value of the output energy can be roughly estimated as:

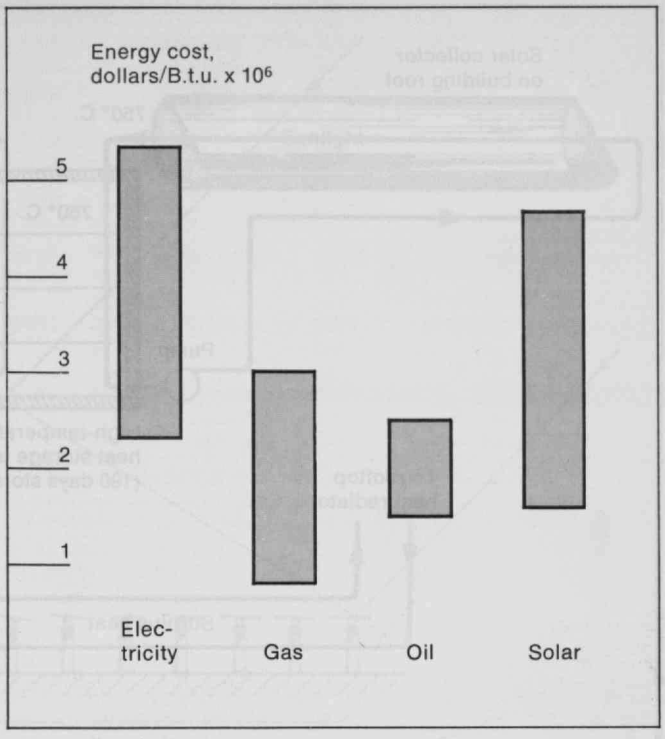
Electric power:

250 working days @ 12 hr. $\times$ 670 kw. $\cong$ 2.00×10^6 k.w.h.

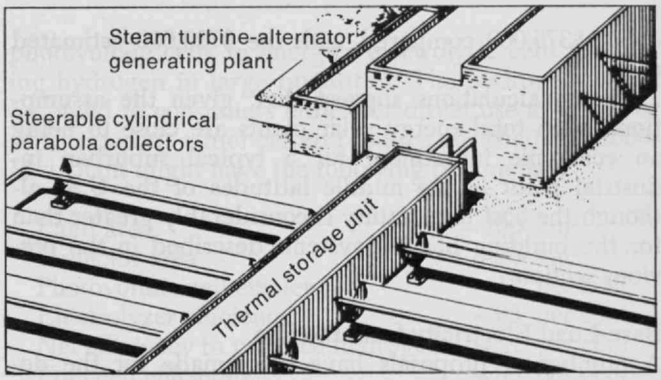
115 standby days @ 24 hr. $\times$ 100 kw. $\cong$ 0.27×10^6 k.w.h.

2.27×10^6 k.w.h.

2.27×10^6 @ \$0.018/K.w.h. $\cong$ \$41,000



Solar systems may now be competitive in total installation and operating cost with gas and oil for domestic space and hot water heating in the most favorable parts of the U.S. As the price of fossil fuel rises faster than the general rate of inflation in the future, solar energy will become increasingly attractive in less favorable areas. Indeed, the author suggests that the balance may have shifted to favor solar energy in much of the U.S. by 1983.



The largest solar systems now envisioned are proposed for medium sized base-load electric power installations. This system is for a 1,000-Mw. plant—utilizing large numbers of one-axis-steerable concentrators to collect high-temperature heat to drive conventional steam turbines. An area 16 km.^{2} would be occupied by collectors for such a plant.

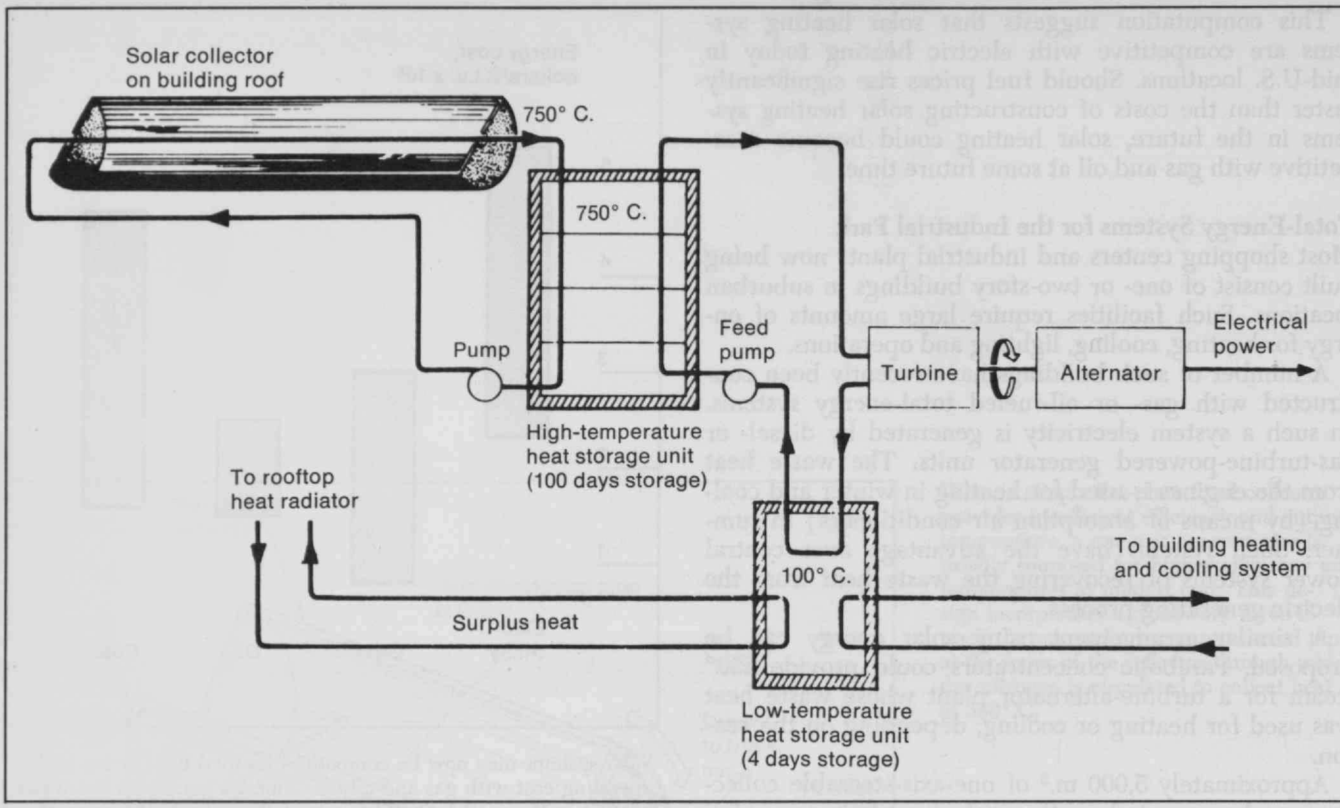
Low-temperature heat:

365 days @ 24 hr. $\times$ 500 kw. $= 4.4 \times 10^6$ K.w.h. $= 1.5 \times 10^{10}$ B.t.u.

Value of 1.5×10^{10} B.t.u. of natural gas @ 23¢/10^5 B.t.u. $\cong$ \$34,000

Total energy value per year $\cong$ \$75,000

The value of this annual energy savings to a typical suburban building can be estimated using typical procedures for calculating industrial plant capitalization. At an 8 per cent discount rate with inflation of 4 per cent/yr., straight-line depreciation, and a 48-per-cent tax rate, this value of the energy savings can be calculated to equal about five times the annual savings or



This solar-powered total-energy system is projected for use in suburban shopping centers or industrial plants where space for solar collection is available. One-axis-steerable concentrators would be located on the roof; high-pressure dry nitrogen, steam, or sodium chloride would transfer heat at 750° C. to a high-temperature storage unit of insulated rocks or molten salt. Heat drawn from the storage unit would drive a turbine to produce electrical power and then, held in a low-temperature storage unit, would be available for space heating or air conditioning.

about \$375,000 compared with the \$720,000 estimated costs.

These calculations suggest that, given the assumptions, such total-energy solar plants are close to being an economic investment for a typical suburban industrial plant in the middle latitudes of the U.S., although the cost uncertainty is considerably greater than for the building heating systems described in the previous section.

Base-Load Electricity from the Sun

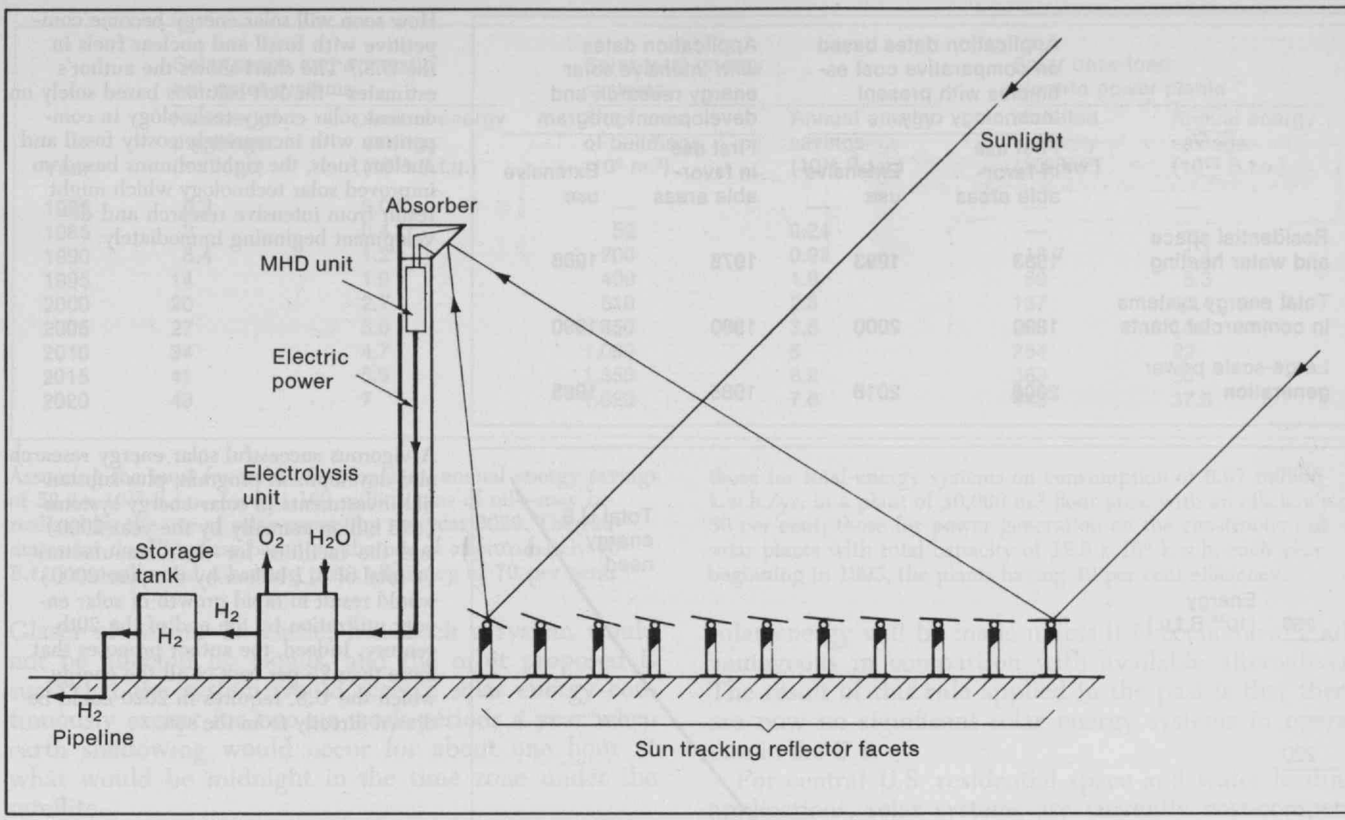
A number of proposals have been made for the design of large-scale solar-powered electric generation systems. (Such plants could also generate hydrogen fuel either from electricity through electrolysis or directly from thermal energy by one of several proposed processes.) These suggestions generally fall into one of the following three classes: ground-based thermal conversion systems using conventional collectors, ground-based systems based on photovoltaic arrays, or systems based on photovoltaic arrays mounted on satellites above the earth.

Proposals for large-scale ground-based thermal conversion systems suggest plants similar in design to the total-energy plant described above. One proposal by Drs. A. B. and M. P. Meinel of the University of Arizona includes one-axis-steerable cylindrical parabolas as solar energy concentrators, with vacuum-insulated heat collection pipes at the focal points of the collectors. The energy would be stored as thermal energy in molten salt or in rock, and conventional steam turbines and alternators would be used to produce electricity. Parameters of a 1000-Mw. continuous-output plant would be:

Area of plant	30 km.^{2}
Area of collectors	16 km.^{2}
Outlet temperature of collectors	550° C.
Collection efficiency	~60 per cent
Thermal storage rock:	2×10^7 m.^{3}
Thermal plant efficiency	~40 per cent
Overall efficiency	~25 per cent

The collector efficiency is reduced from the previous case because of the long distance involved in transferring heat from the collector to the steam plant. Assuming that collector costs can be reduced to \$60 per square meter and using the same cost assumptions for the other components as for the total-energy plant, a total system cost of about \$1.4 billion is calculated, corresponding to \$1,400 per kw. of capacity. Separate studies of this type of solar plant by Aerospace Corp. have suggested capital costs of \$1,000 to \$2,000 per kw. of capacity for similar designs.

In steady operation over a one-year period, such a 1,000-Mw. plant would produce about 8.8×10^9 k.w.h. At a wholesale value of \$0.08/k.w.h., the year's output would have a value of about \$70 million. Using the same capital valuation assumptions as in the case of the total-energy plant, a plant investment of about \$350 million could be justified. This is about one-fourth of estimated cost. Obviously, substantial reductions in the solar plant cost and/or increases in the value of electricity would be required before such solar plants would be justified.



If solar heat can be used to drive a magnetohydrodynamic power generator, the system might look like this. A two-axis concentrator consisting of a large number of movable reflectors focusses energy at extremely high temperature to operate an MHD power unit. Energy from the power unit is used to produce hydrogen by electrolysis, the hydrogen then to be supplied directly to consumers or placed in storage for use when solar energy is not available.

An alternative design for a ground-based thermal plant using a two-axis concentrator which consists of a large number of individually movable facets has been proposed by A. F. Hildebrant, G. M. Haas, W. R. Jenkins, and J. P. Colaco of the University of Houston. Each facet would independently track the sun so as to reflect sunlight on a central collector mounted on a tower at one edge of the array. A magnetohydrodynamic thermal-electric system mounted at the collector would be used to produce hydrogen by electrolysis. Tanks of hydrogen at the plant would provide the energy storage.

Typical parameters for a plant with 1,000 Mw. continuous output might be as follows:

Area of plant	17 km.^{2}
Area of collector	17 km.^{2}
Collector efficiency	~60 per cent
Conversion efficiency to electricity	~60 per cent
Conversion efficiency to hydrogen	~90 per cent
Overall efficiency to hydrogen	~32 per cent

Detailed cost estimates for this class of system are not available, but costs would probably be of the same order as for the previously described ground-based system.

Solar Cells on the Ground and in Space

Large-scale ground-based plants based on photovoltaic collectors have been proposed, using arrays of silicon photovoltaic cells to energize electrolytic cells producing hydrogen in large quantities. The hydrogen would be piped to consumers either for direct use as a fuel or as an input to a fuel cell to produce electricity. A 1000-Mw. plant might have the following parameters:

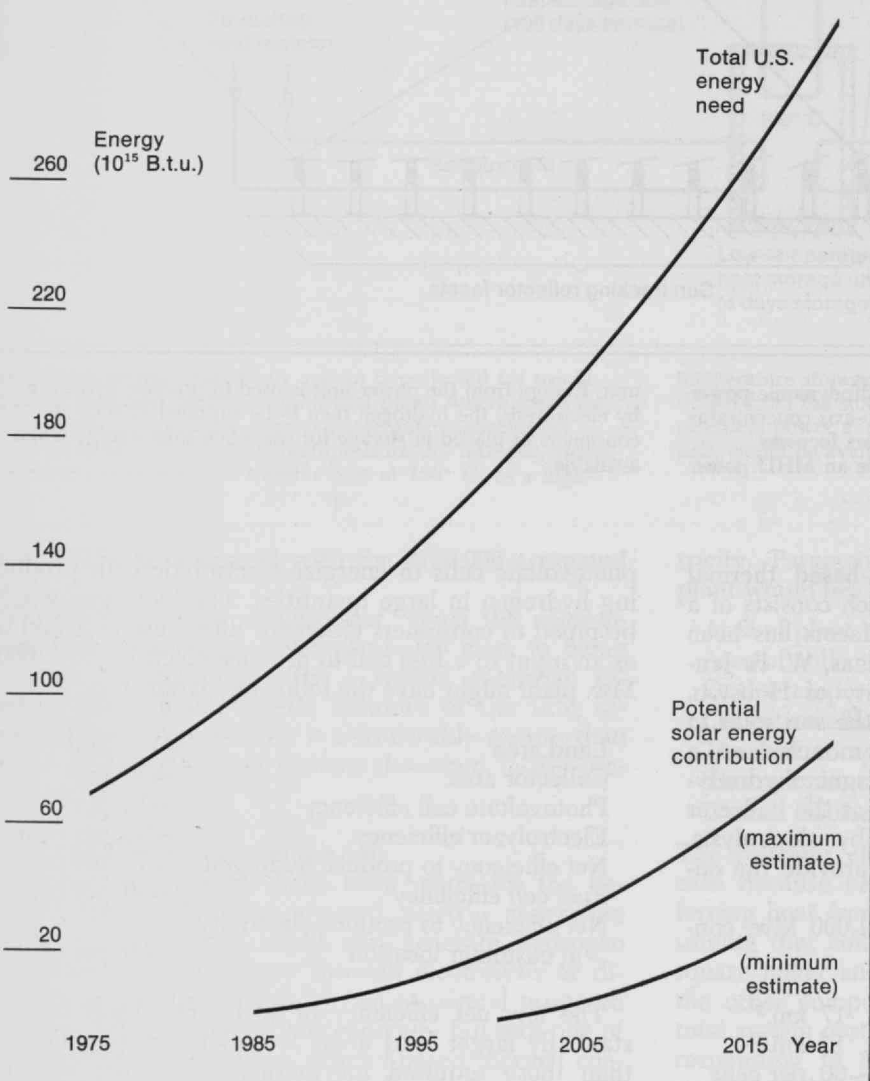
Land area	~100 km^2
Collector area	~50 km^2
Photovoltaic cell efficiency	~12 per cent
Electrolyzer efficiency	~95 per cent
Net efficiency to produce hydrogen	~11 per cent
Fuel cell efficiency	~80 per cent
Net efficiency to produce electricity at customer location	~9 per cent

The low net efficiency of such units leads to substantially larger land areas for solar energy collection than those required for thermal-cycle solar systems. A much more difficult problem, however, is the high cost of the photovoltaic cells; at present prices, costs would exceed $100,000 per kw. of capacity. Cost reduction by a factor of at least 300 is required to achieve reasonable costs, and many years of intensive development will clearly be required to achieve this goal—if in fact it is attainable. An alternate approach to cost reduction would be the use of a one-axis concentrator, yielding reduction by a factor of 50 in the required solar cell area; but cells for such applications would have to be specially designed to accept energies of up to 50 times the sun's intensity.

Solar power plants mounted in satellites in synchronous earth orbit have been proposed by Peter E.

	Application dates based on comparative cost estimates with present technology only		Application dates with intensive solar energy research and development program	
	First use in favorable areas	Extensive use	First use in favorable areas	Extensive use
Residential space and water heating	1983	1993	1978	1988
Total energy systems in commercial plants	1990	2000	1980	1990
Large-scale power generation	2006	2016	1985	1995

How soon will solar energy become competitive with fossil and nuclear fuels in the U.S.? The chart shows the author's estimates—the left columns based solely on current solar energy technology in competition with increasingly costly fossil and nuclear fuels, the right columns based on improved solar technology which might result from intensive research and development beginning immediately.



Year	Total annual output of solar energy systems 10^{15} B.t.u.	Per cent of total U.S. energy demand filled by solar energy
1975	—	—
1980	0.04	0.05
1985	0.64	0.5
1990	4.4	3.6
1995	13	8.7
2000	23	13
2005	33	16
2010	47	20.4
2015	63	23.8
2020	78	26

A vigorous successful solar energy research and development program, plus substantial investments in solar energy systems ($25 billion annually by the year 2000) and the facilities for their manufacture (a total of $11 billion by the year 2000) would result in rapid growth of solar energy utilization by the end of the 20th century. Indeed, the author proposes that more than 25 per cent of all the energy which the U.S. requires in 2020 could be drawn directly from the sun.

Year	Solar space and domestic hot water systems: Number of dwellings (millions)	Annual energy savings (10^{15} B.t.u.)	Solar total-energy systems: Floor area of buildings (10^6 m.^{2})	Annual energy savings (10^{15} B.t.u.)	Solar base-load electric power plants: Installed capacity (10^6 kw.)	Annual energy savings (10^{15} B.t.u.)
1980	0.3	0.04	—	—	—	—
1985	3	0.4	52	0.24	—	—
1990	8.4	1.2	200	0.92	18.7	1.4
1995	14	1.9	400	1.9	69	5.3
2000	20	2.7	610	2.8	137	10.4
2005	27	3.6	850	3.8	208	15.2
2010	34	4.7	1,090	5	284	22
2015	41	5.9	1,350	6.2	363	30
2020	49	7	1,620	7.6	445	37.6

Assuming the most favorable development, annual energy savings of 52.2×10^{15} B.t.u.—over 1,160 million tons of oil—may be realized by the use of solar energy by the year 2020. The estimates for dwellings are based on the use of approximately 10^8 B.t.u. annually and a heating plant efficiency of 70 per cent; those for total-energy systems on consumption of 6.67 million k.w.h./yr. in a plant of 10,000 m.^{2} floor area, with an efficiency of 50 per cent; those for power generation on the construction of solar plants with total capacity of 12.5×10^6 k.w.h. each year beginning in 1995, the plants having 40 per cent efficiency.

Glaser of Arthur D. Little, Inc. Such a system would not be affected by clouds, and the orbit proposed is such that the system would receive solar energy continuously except for two six-week periods a year when earth shadowing would occur for about one hour at what would be midnight in the time zone under the satellite.

The proposal is to use photovoltaic cells to produce electricity as direct current, which would then be converted to radio energy at microwave frequency (3,000 MHz.) for transmission to the earth's surface where conversion to a.c. power would occur. All the components of the system would be massive by any scale with which we are familiar: the satellite-mounted transmitting antenna would be 1.4 km.^{2}, and the receiving antenna on earth would cover a square 10 km. on each side. The satellite would carry an array of solar cells about 7 km. square, giving an output power of 10^7 kw. —sufficient, for example, to meet the electrical power needs of New York City. Parameters for such a satellite would be:

Size of satellite microwave transmitting antenna	1.4×1.4 km.
Size of ground microwave receiving antenna	10×10 km.
Efficiency of solar cells	15 per cent
Efficiency of microwave transmission system	70 per cent
Projected weight in orbit	2.2×10^6 kg.

Such a system could be competitive in cost with conventional power plants or even some of the proposed ground-based solar power plants only with very substantial reductions from present satellite launch costs (by a factor of 50 to 1) and solar cell costs (by a factor of 1000 to 1). Very substantial advances in technology are required to achieve such cost reductions.

Economics vs. the Sun: When Solar Energy?

From this range of possibilities for the utilization of solar energy, what applications may we envision for the next few decades?

The first point to be made in answering that question is the lesson of basic economics: no application of solar energy will be made unless it is economically advantageous in comparison with available alternatives. The result of this rule applied in the past is that there are now no significant solar energy systems in operation in the U.S.

For central U.S. residential space and water heating applications, solar systems are currently cost-competitive with electric energy and within a factor of 1.5 of being cost-competitive with gas- and oil-fueled systems. In these same locations total-energy solar systems are probably within a factor of two of being cost-competitive with fossil-fueled systems, and large-scale ground based solar electric plants are within a factor of four of competing with electric plants fueled with conventional energy sources.

There are good reasons for believing that many of these solar-powered systems may become economically attractive in the years to come. This prediction is based on the probability that the costs of energy derived from conventional sources such as fossil fuels and nuclear fission may rise faster in the future than the costs of building solar energy systems. Indeed, the latter may be lowered through a vigorous research and development program which places significant emphasis on economical design and production techniques.

The rationale for the costs of conventional fuels to rise faster than any general rate of inflation is based on two predictions: inexpensive fuel resources will gradually be depleted, and continued increasing demand will force higher prices from all available sources. A Dow Chemical Co. study has projected cost increases in the period from 1974 to 1980 of 8.4 per cent a year for oil and gas, 10 per cent a year for electricity, and 6.7 per cent a year for coal. Current costs of nuclear plants are increasing sharply because of increasingly stringent safety regulations, and limitations on the supply of uranium can be expected to force fuel price increases. All such projected rates of energy price increase are well in excess of the 4 per cent long-term inflation in materials and services costs which most economists foresee during the current decade. Indeed, only a technical and economic success with the breeder reactor might basically affect these energy cost projections; fusion power systems are not considered to be a factor in the current century.

Assuming successful research and development and continued increases in the cost of fossil fuel, a U.S. solar-energy industry may grow rapidly to supply 8.4 million dwellings by 1990 and 69 million kw. of base-load electric power by 1995

Required annual capital expenditures (billions of 1973 dollars)

Year	House heating	Total-energy systems	Electric plants	Hydrogen plants	Total
1978	$0.2	—	—	—	$ 0.2
1980	0.8	—	—	—	0.8
1985	3.2	$0.9	—	—	4.1
1990	4.2	1.8	$4.4	$4.4	15
1995	4.4	1.9	8.8	8.8	24
2000	4.5	2.0	9.1	9.1	25

If the author's forecasts of technological and economic developments are fulfilled, solar energy will become increasingly competitive with other energy sources during the last 20 years of the 20th century, and there will be large capital expenditures in solar energy systems. Indeed, by the year 2000 such annual expenditures could total at least $25 billion.

On the basis of an average annual increase in fuel and electricity costs of about 8 per cent and a general price inflation (including solar energy systems) of 4 per cent, one can estimate the dates when various types of solar energy systems might become less expensive than fossil-fueled alternative energy sources. Such calculations suggest that solar energy, now 1.5 times as costly as fossil fuels for residential space and water heating, may be competitive for this purpose in favorable areas of the U.S. such as the southwest—where the climate is moderate and sunshine relatively plentiful—by 1983, and that it may come into extensive use (as a result of a further 50 per cent cost differential) by 1993, when it would be competitive for residential applications in most U.S. climates. Similar calculations suggest that solar-powered total-energy systems for commercial plants might first appear practical in 1990 and come into more extensive use by the year 2000, and that comparable dates for large-scale solar-based power plants are 2006 and 2016.

Two factors may affect these estimates. One is any future development of nuclear technology which may act to reduce the cost of nuclear power. The other is the possible effect of an extensive solar energy research and development program. Cost improvements in solar energy systems by a factor of two seem relatively easy to achieve given even modestly successful technical innovation, and such improvements might be demonstrated in three to five years in installations of modest size. This could lead to the first extensive use of solar heating systems by 1978 and of total energy systems by 1980. Additional intensive development during the next five years could make large-scale solar plants competitive by 1985. All these estimates are summarized in the accompanying tables.

The Growth of the Solar Industry

How rapidly might solar energy systems gain acceptance in the U.S.? The following estimates are made on the basis of two assumptions: that solar energy is applied only to new installations (i.e., that no retrofitting is done); and that rates of investment in new houses, industrial plants, and power plants continue in the future at approximately present levels.

In the case of residential space and water heating systems, a total building rate of 2 million units per year is assumed, of which one-half might be suitable for solar heating. Installation would begin in 1978; the rate would rise linearly to 1 million per year in 1988, and thereafter installations would increase in proportion to population growth. By 1990, with 8.4 million dwellings equipped with solar systems, annual savings could be 1.2×10^{15} B.t.u., equivalent to 30 million tons of oil.

An estimate of the maximum rate of application of solar total-energy systems to commercial and industrial buildings can be made by noting that, on the average, approximately 2×10^7 m.^{2} of industrial floor space are constructed every year. Assuming that half of this construction is single-story and suitable for solar total-energy systems and that such systems are available by 1980, installations associated with 3.5×10^7 m.^{2} of construction per year might be achieved by 1990. By then, annual energy savings of 92×10^{13} B.t.u., or 23 million tons of oil, could be achieved.

In 1970-71, electric generating capacity was being constructed at the rate of about 25×10^6 kw. per year. If it is assumed that large-scale electric power production by solar energy can begin in 1985 and that by 1995 one-half of all new electric power installations are solar-powered, 69 million kw. of base-load electric power generation will then be from solar energy, with

an annual saving of 131 million tons of oil or its equivalent.

One may postulate that some of the solar electric power proposed above would be redundant with solar home heating or total-energy commercial units. But one may also propose that many other energy requirements —buildings inappropriate for solar power because of siting or multi-story construction, industrial processes, and transportation—could be supplied with energy in the form of hydrogen or hydrogen-derived fuels produced by large-scale, high-efficiency solar-powered plants.

Though there are no proven methods of directly producing hydrogen at high efficiency (70 per cent or better) from solar energy, a number of multi-stage thermally driven chemical processes seem to have promise. If one assumes that the costs per unit area of collector will be the same for hydrogen plants as for base-load solar-powered electric plants, that such plants are built at the same rate (rated in terms of solar collection area) as electric plants, and that the efficiencies are of the order of 70 per cent, the energy savings will be about 70 per cent of those achieved by construction of solar-powered base-load electric plants. Construction might be feasible by 1990, and projected energy savings by the year 2000 are some 180 million tons of oil.

The estimates of solar energy utilization developed in the preceding paragraphs can be combined to indicate total possible energy savings for the U.S. through solar energy development. As the chart (*p. 39*) indicates, these savings may begin to be significant during the last decade of this century. The growth in solar energy output projected here is set primarily by the capital investment assumptions given earlier. But other factors may also affect the validity of these estimates. If energy demands can be moderated through conservation programs or under the influence of higher prices, solar sources could meet a larger percentage of total U.S. energy need than indicated.

If development funding lags or if opportunities for applications are more limited than assumed, a much lower utilization of solar energy would result—the minimum contribution shown in the chart. But it is clear that in either of these situations solar energy has the possibility of contributing very significantly to the country's energy needs. (A third possibility is that a new energy source—such as nuclear fusion—may turn out to be less expensive and more readily available than solar energy systems. In that case, very few if any solar systems will be built.)

One point needs emphasis: no breakthroughs are needed to make solar energy feasible. All that is required is to engineer solar energy systems which are less costly than current designs by a factor of 1.5 to 4 depending on the type of application—except that considerably greater cost reductions will be necessary to make practical photovoltaic solar plants.

It is fair to say that the engineering problems to be solved in making solar energy practical are considerably simpler than those of the breeder reactor and *far* simpler than those which must be solved in devising a practical fusion reactor. Yet it is also fair to say that a substantial research and development program, together with a vigorous implementation program, will be required to confirm that solar energy may in fact provide a significant portion of the nation's future energy needs.

An Agenda for Research and Development

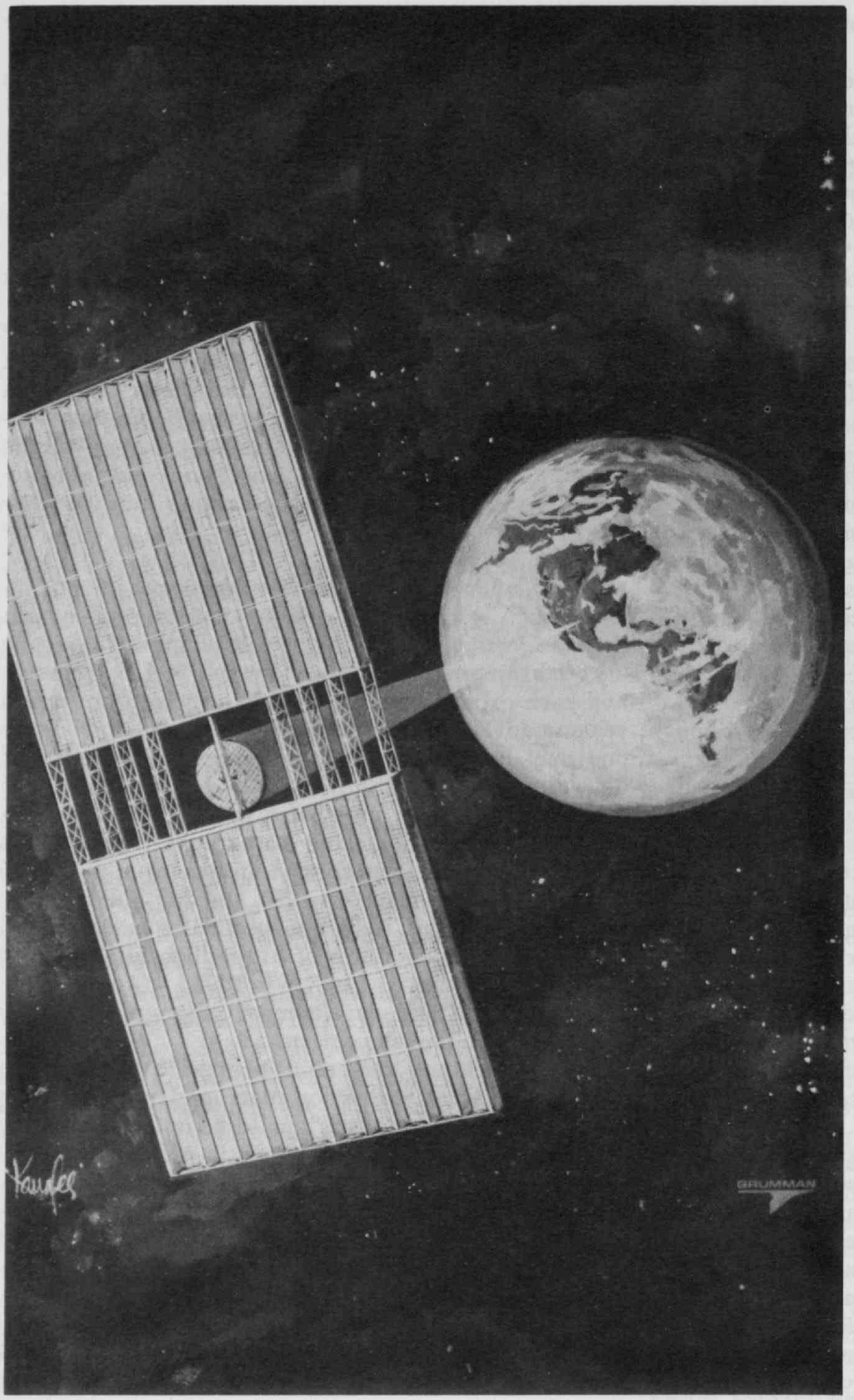
How much research and development investment can be considered? About 4.5 per cent of sales is typically devoted to research and development in U.S. industry, and such expenditures are usually required about five years in advance of the beginning of production. Hence one may hypothesize that solar energy research and development expenditures should be computed as 4.5 per cent of the sales anticipated five years hence. Data developed in the following paragraphs suggest sales of $200 million in solar energy equipment in 1978, $15 billion (in 1973 dollars) in 1990, and $25 billion in the year 2000. On this basis one postulates research and development expenditures of $10 million in 1973, $670 million in 1985, and $1.1 billion in 1995.

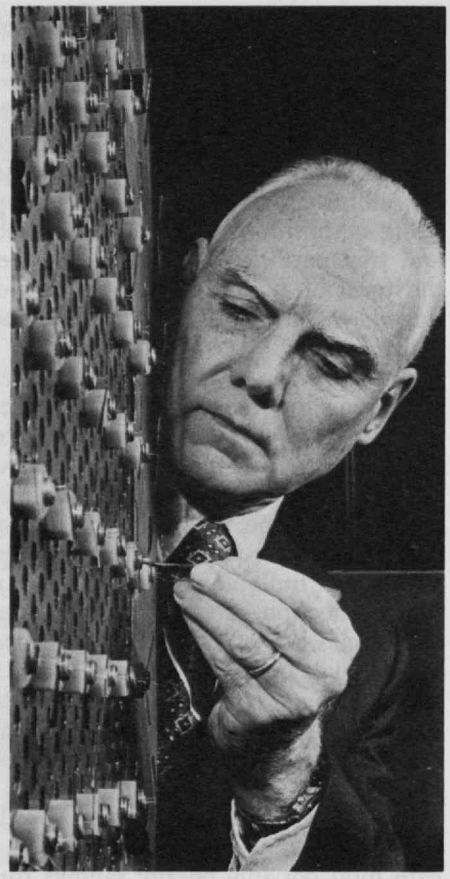
The research and development program should include efforts in the nine areas:

—Development of low-output-temperature (less than 200° F.) solar collectors for space and water heating applications. The emphasis should be on achieving low cost and high collection efficiency in a design compatible with housing construction practices.

—Development of inexpensive low-temperature energy storage techniques capable of holding sufficient energy to heat a house for several days, in designs compatible with housing construction practices.

—Development of low-cost high-efficiency solar collectors for applications requiring high output temperatures (500° C. to 1000° C.) such as electric power





Peter E. Glaser and his associates at Arthur D. Little, Inc., are the creators of this concept (left) for a satellite solar power station to be placed in synchronous earth orbit. Energy converted into electricity by solar cells in the power station is to be transmitted by an electromagnetic link to a receiving antenna on earth (the photo above shows a prototype, on which William C. Brown of Raytheon Co. is working), with an overall efficiency from space to earth of about 70 per cent. The location in space would give the satellite a clear view of the sun, unaffected by weather and day-and-night cycles, and this is said to yield a six- to 15-fold advantage compared with terrestrial solar power installations.

plants using thermal cycles and hydrogen fuel production processes. Areas for study include absorbing surfaces with low emissivity, heat mirrors, insulation techniques, inexpensive solar trackers, heat transfer systems, and techniques for cleaning the collectors.
—Development of economical high-temperature thermal energy storage systems. Areas of possible effort include molten salts, rocks, and metals as heat storage media; insulation techniques; heat transfer systems; and techniques for combining such devices with solar collectors and thermal-cycle generating plants.
—Development of improved photovoltaic solar cells having increased efficiency and lower cost than contemporary designs.
—Development of solar concentrators for use with photovoltaic solar cells.
—Development of inexpensive electrical energy storage techniques for use with photovoltaic solar cell systems.
—Detailed surveys of solar intensity variations in possible areas of application.
—Systems studies on various applications of solar energy with emphasis on system costs, financing methods, and the problems of interfacing solar energy with various processes and systems which now consume energy.

In addition to the above, successful research and development on high-efficiency energy conversion techniques for electric power and hydrogen fuel production would contribute significantly to the early realization of solar energy systems.

$36 Billion for Solar Energy by 2000

Success in these research and development efforts will make possible the rates of application postulated above. But if these rapid advances are to occur, large capital investments will also be required. To simplify the earlier discussion, the cost of the various types of solar energy systems can be projected as follows:

Residential solar heaters	$4,000 each
Total-energy plants	$50/m.^{2} of building supplied, or $100/m.^{2} of collector area
Electric base-load power plants	$700/kw. of electrical output power, or $40/m.^{2} of collector
Hydrogen production plants	$40/m.^{2} of collector

These costs, taken with the application rates developed above, yield the capital expenditure rates shown in the table on page 40—an annual expenditure of $25 billion (1973 dollars) to be invested in solar heating and energy systems by the year 2000.

To these figures must be added the cost of the substantial number of production plants needed to make such large numbers of solar-energy devices and facilities. A crude estimate of this required investment in production facilities can be made by extrapolating from the fact that manufacturing in the U.S. now requires plant investments equal to about 45 per cent of annual output. The plant is depreciated, on the average, over about 14 years. On this basis an investment of $11 billion (1973 dollars) in solar plant production facilities is indicated by the year 2000.

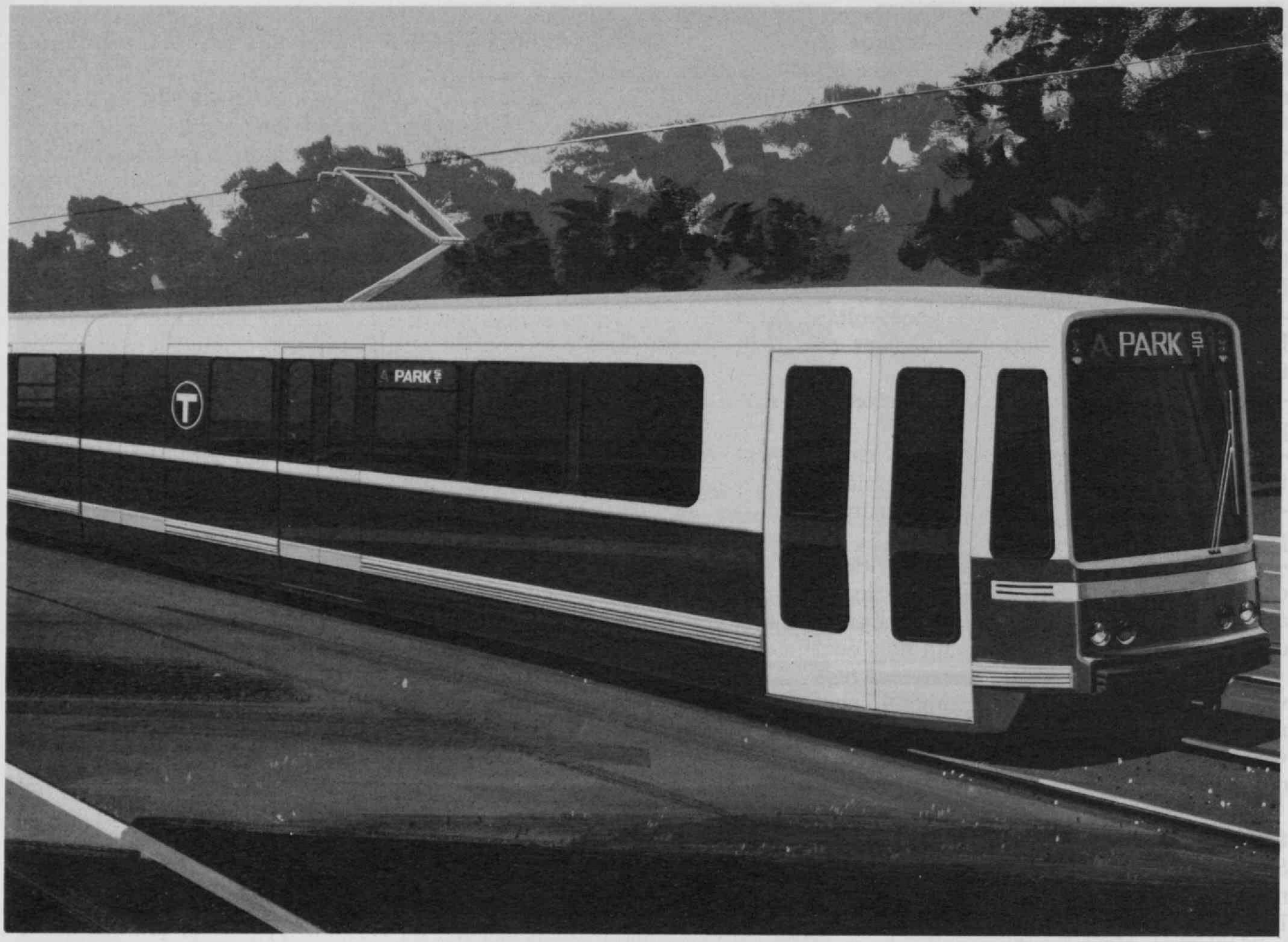
Combining the cost of research and development, production facilities, and the systems themselves gives a total solar-energy investment of about $300 billion in the next 27 years. As the table on page 38 shows, investment at that level would mean that 13 per cent of projected U.S. energy requirements could be filled by solar systems in the year 2000, 26 per cent in 2020.

While substantial collector areas would be required, the total area involved by the year 2020, about 10^4 km.^{2}, would be much less than that used currently for highways. In fact, a substantial fraction of the collector area needed could be accommodated on the roofs of buildings; the rest could be accommodated on land shared with farming or grazing.

The large-scale use of solar energy should have a minimal environmental effect, since such systems operate from an almost inexhaustible energy source external to the earth, produce no pollution products, and can be designed to have minimal effect on the earth's heat balance.

Walter E. Morrow has been a member of Lincoln Laboratory since its founding—the year he completed studies in electrical engineering (S.B. 1949, S.M. 1951) at M.I.T. During this period he has been active in research on a wide variety of radio communications techniques, equipment, and systems; and he has held positions of continually increasing responsibility, becoming the Laboratory's Associate Director in 1972. This article is based on a paper prepared for a technical task force of the Federal Power Commission.

How can urban transit regain the confidence and markets which have been lost in decades of stagnation? Financial help from government is only part of the answer



With help from the Department of Transportation, the Massachusetts Bay Transportation Authority and the surface transportation system of San Francisco are jointly commissioning these new cars for use on existing surface lines. In Boston the new equipment will serve the "Green Line," providing a markedly quicker and more comfortable trip from Riverside Station on Route 128 to the center of "the Hub." (Photo: M.B.T.A.)

David R. Miller
Senior Associate
Barton-Aschman Associates, Inc.

Financing Mass Transit: Mobility Is Among the Assets

"Back to Boston, back to Boston
Where the subway's in a hole
You may find it nice and comfy during seasonal gales
But you mustn't be astonished when the service fails
It may be the finance company has taken the rails
Back in Boston, U. S. A."

In the late 1940s, when a bright young undergraduate named Joe Gottlieb was writing songs like the above for M.I.T.'s Tech Show, Boston's Metropolitan Transit Authority was already in financial difficulties, a curiosity among transit firms in its inability to show a profit. Today, the urban transportation operation that *does* show a profit is a curiosity.

By virtually any measure, the urban mass transit industry has been in decline for at least 20 years. Employment, fleet size, and number of passengers carried have all fallen. Gross revenues have remained fairly stable in the recent past, but this is because fare increases have offset the decrease in ridership. Prospects for the industry generally are not bright, and private ownership is waning rapidly: Of the transit properties in our ten largest cities, only Houston's is still in private hands; many medium-size cities' transit firms have already "gone public"; and mass transit has disappeared entirely in a large number of cities of less than 100,000 population.

By now, the plight of public transit is a familar story to most people. Many reasons have been offered for its decline; highway construction has come in for more than its fair share of the blame. There is no need to review the many reasons for the problem, nor is hindsight productive. Passage of the Urban Mass Transportation Act of 1964 and the Urban Mass Transportation Assistance Act of 1970 at the federal level, and of many pieces of transit legislation at state and local levels, indicates a growing acceptance of the concept that transit is a public good rather than one to be produced by the private sector of the economy. With a few exceptions, however, the legislation passed to date has failed to come to grips with a very important aspect of public goods: financing.

Summary of Transit Legislation

It may appear paradoxical to assert that bills which include substantial appropriations fail to deal with financing. A brief overview of existing legislation will help explain the assertion.

Federal aid to transit is concentrated in three areas:

—Technical studies funds, which are given to cities to help them in planning mass transit facilities as part of a comprehensive planning effort.

—Capital grants, which are the biggest dollar outlays, particularly since passage of the Act of 1970, which authorized expenditures of $3.1 billion on mass transit in the subsequent five years.

—Research, development, and demonstration funds, which are self explanatory.

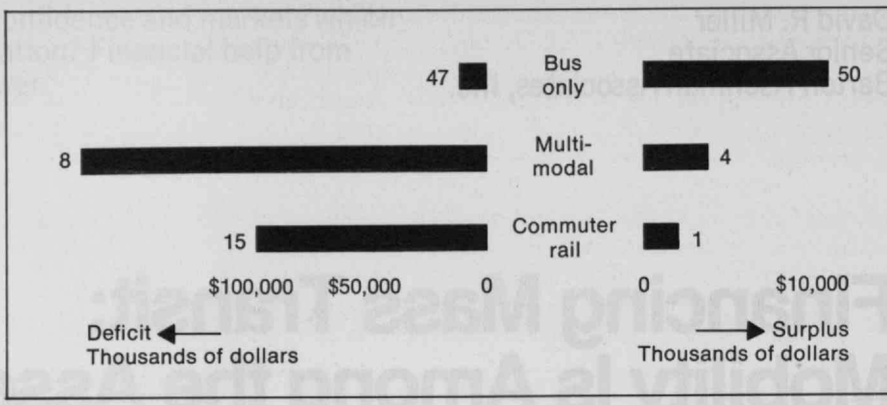
Substantial support for the federal legislation came from the largest cities, especially those with commuter railroad operations. Large cities were faced with deteriorating service and threats of discontinuance; officials had nightmares about the traffic jams that would result if the threats materialized. It was thought that capital grants, used to purchase systems, provide new equipment, or upgrade existing equipment, would enable transit to get back on its feet. In medium-size cities, threats by local bus operators to discontinue service entirely were increasingly frequent; again, federal capital to aid in public takeover of transit operations appeared as an unmixed blessing. With new equipment, the elimination of alleged private-sector inefficiencies, and the tax relief that would come with public ownership, transit could pay its own way out of the farebox.

Congress was confronted with appeals from a coalition of elected city officials and transit industry representatives. Some members of Congress, representing urban constituencies, were themselves strong transit advocates. Accordingly, the capital grant legislation was passed.

Even before the federal government added its support for mass transit, a number of localities had enacted legislation providing for public operation of transit. This legislation took many forms, varying from outright city ownership of transit properties (with their operations organized as a city department) to the ability to contract with private operators for specific services—the latter form given considerable impetus by passage of the Housing Act of 1961 with its provision for demonstration grants—which had to be administered by public bodies.

Although the view that transit was a public good and public responsibility gained increasing acceptance in the 1960s, the idea that it ought to be run like a private enterprise, meeting its expenses from sale of its product, did not decline concurrently. Very few of the "old-time" public transit operations, however, enjoyed any revenue

The data above summarizes the financial performance in 1969 of 125 firms and public authorities providing urban and suburban transport services covering 85 per cent of all urban transport passengers. Of 12 multi-modal operators (bus, streetcar, subway, and/or railroad systems), eight reported deficits totalling about $166 million; one of these—the New York Transit Authority—accounted for nearly $100 million of this figure. Of 47 bus operators reporting deficits, three accounted for nearly half of the total losses of $15 million.



from sources other than the farebox. In fact, the indentures for the revenue bonds which several cities had used to finance the purchase of their transit systems stated specifically that fares would be set at a level adequate to cover debt repayment, interest, and operating expenses. While public ownership might permit a transit operation a free hand in setting fares, it would not relieve the operation from the workings of demand elasticity. As costs rose and fares were increased, ridership declined.

In the classic economic model, a true public good has external benefits which cannot be entirely recovered by user charges, and sources of revenue other than user charges are required to meet the full costs of providing the good or service. Apparently few if any of those arguing for public takeover and federal capital grants to transit had considered the implications of the course of action they advocated.

Pressure for Operating Subsidies

The ink was scarcely dry on the Act of 1970 before the transit lobby—which now included a number of cities owning and operating their transit systems) discovered it had a new crisis on its hands. Ridership declines were not only continuing, they appeared to be accelerating. At the same time, wage demands of transit labor were growing, and many now public transit systems had discovered they were no longer able to prove poverty to a union by showing it their empty farebox. The problem was exacerbated by some well-publicized arguments about who bore the responsibility for pension payments after public takeover of some major private firms. Typically, pensions in the transit industry had been paid out of current revenues. Transit labor suddenly realized that such schemes were actuarially unsound and without adequate protection for retirees in the event of continued financial crises. Labor negotiations became progressively more difficult.

For a variety of reasons, transit again looked to Washington for relief where the cry in previous campaigns had been, "We need capital grants to get us back on our feet," now it was, "We need operating subsidies to stay alive."

In all fairness, it must be stated that the transit lobby had very real financial problems and a sound basis for seeking federal aid. As part of the Urban Mass Transportation Assistance Act of 1970, Congress instructed the Secretary of Transportation to study and report on the feasibility of operating subsidies. His report submitted to the Congress in November, 1971, was weighty—69 pages of text and 62 pages of appendices. It discussed the present condition of the urban mass transportation industry and existing transit assistance programs. After analyzing the alternative forms a federal operating assistance program might take, the report concluded that none could be recommended at the time, although further study of the problem was justified. The report also recommended that Congress enact the President's Special Revenue Sharing proposal.

The report, of course, did not settle the issue. The transit lobby merely turned its attention to Capitol Hill, and in the next two years, different bills authorizing operating subsidies were passed by the Senate and the House. The Administration is still taking a public stand against the provision of operating aid, but how the President will act if he is confronted by a bill passed by both houses of Congress remains to be seen.

The Trouble with Subsidies

If the transit industry is in admittedly poor shape, what is the objection to federal operating subsidies? There is always the statement that transit industry deficits are a symptom, not the problem, but beyond that, and the philosophical issue of the federal role in states and cities, there is a serious administrative problem. It arises from the facts that cities differ from one another, and subsidy programs are expected to meet many objectives simultaneously. So far it has proved impossible to devise a formula for giving out operating subsidies that are equitable, that will keep transit firms solvent and enable them to increase the mobility of city-dwellers, that are efficient (in the economic sense of not leading to distortions in resource allocation,) that will encourge innovation, and that can be administered at reasonable cost. To over-simplify, a subsidy mechanism that distributes enough money to keep certain firms from insolvency will result in huge windfalls to other firms, while a mechanism without windfalls is likely to be either inequitable or of little help to cities with major transit financial problems.

One of the difficulties in distributing subsidies is the distribution of transit deficits. The table on this page provides an overview of the issue. Bus-only firms (1,150 in number, according to the American Transit Association) are those which provide urban transit service by motor bus only. The "multi-modal" firms provide service by rail rapid transit on separated right-of-way, surface streetcar, trackless trolley, or other modes. These

firms are concentrated in less than a dozen cities. Some provide rail service only—for example, the Delaware River Port Authority's Lindenwold High-Speed Line. Others provide service by virtually every conceivable mode; Boston's M.B.T.A. and Philadelphia's S.E.P.T.A., are examples. Commuter rail service is provided by 16 railroads in Boston, New York, Philadelphia, Washington, and Chicago; a small amount of service is offered in Pittsburgh, Los Angeles, and San Francisco.

The sample in the table includes 97 bus-only firms, 12 multi-modal firms, and 16 commuter railroads. They carried about 85 per cent of urban transport passengers in 1969, and amassed a 1969 gross deficit of about $276 million. The deficit, however, was by no means uniformly distributed among firms in the sample.

Of the bus-only firms, three accounted for 49 per cent of the reported bus-only deficit; three-quarters of the deficit was incurred by nine firms, 90 per cent by only 20 firms.

In multi-modal operations, the New York City Transit Authority reported just under $100 million deficit—well over half of the total loss reported by multi-modal firms. Boston's M.B.T.A., with a loss of about $44 million, accounted for another quarter of the loss. None of the other multi-modal firms accounted for more than 7.5 per cent of the total deficit.

Rail statistics are generally reported on a road-by-road basis rather than by city, so the numbers are more difficult to interpret. On one analysis, New York and Philadelphia operations appear to account for about 85 per cent of the total rail deficit. Commuter rail operations appear to incur deficits that are disproportionately high relative to the number of passengers carried. According to one source, about 6.6 per cent of all public transit passengers in New York City commute by rail; 12.1 per cent of Chicago and 14.2 per cent of Philadelphia transit riders are rail commuters; the figures for Boston and San Francisco are 4.0 and 3.0 respectively.

Another way to look at the variance in deficits is on a *per capita* basis. Dividing reported deficits by Standard Metropolitan Statistical Area population, *per capita* deficits for bus-only firms range from 10 cents to well over $3 among the 20 cities with the largest deficits. Among multi-modal firms, some representative figures are: Philadelphia, 22¢; Chicago, 40¢; New Orleans, $8; New York, $9; Boston, $16.

Still another perspective was provided by a consultant to the Department of Transportation, who analyzed the rail rapid transit deficits in an attempt to find a consistent explanation for them. A relatively unsophisticated analysis produced these tentative conclusions: it appeared that New York City's deficit was mainly the result of the low (30¢) fare. Boston's problems seemed to stem from poor productivity. Philadelphia, Cleveland, and Chicago appeared to have population densities barely sufficient to support rail rapid operations, and the revenue allocations between rail and surface operations in those three cities seemed questionable.

These results were by no means conclusive. But they do raise interesting questions about the federal role: If a city lowered its fares well below its costs would the federal government foot the bill for that decision, which is more a political than an economic one? If all transit firms agreed to lavish union contracts in the hope of securing labor peace, would the government underwrite the extra costs? Suppose a city decided to build a major new rail rapid transit line on grounds of civic pride rather than economics. Would the government pay the deficits there, too?

It should be noted that the "deficit" discussed in the preceding paragraph is really the difference between operating revenues and operating costs, not the actual cash shortfall firms experienced in the study year.

Many state and local programs to aid local mass transit are already in effect. The very fact that some localities have been fit to enact such programs while others have not suggests the difficulty of trying to tailor one federal program to fit all national needs. Priorities clearly differ: At one extreme, some local transit authorities have taxing powers and can establish service levels and fares by action of their governing boards. At the other extreme, some cities will insist on regulating transit firms as if they were still profit-making public utilities giving them no tax relief, let alone subsidies. The Secretary of Transportation's 1971 report to Congress devoted 14 of its 69 pages to a discussion of state and local assistance programs for transit. The discussion was strictly a factual narrative and did not note that some localities had managed to help themselves if they wanted transit service.

Analysis of Specific Mechanisms

The tables on the opposite page are analyses of mechanisms to subsidize capital cost (top table), operating cost (middle table), and output-related cost (bottom table). These tables are taken from the 1971 report to Congress, and the figures refer only to the sample of transit firms that furnished operating data through their trade associations to D.O.T. for the 1971 report. Implicit in the organization of the tables is the assumption that a deficit can be traced to specific cost categories.

A few explanatory notes are in order. The capital-cost mechanism listed in the top table as "pay maintenance, etc." actually involved payment for maintenance, garage, and equipment costs for bus-only firms, and maintenance of way and structures for multi-mode and rail properties. This attempts to answer the argument that rail firms are at a disadvantage relative to rubber-tired modes, which do not have to directly pay right-of way costs.

The bottom table shows the effects of a vehicle-mile subsidy and a per-passenger subsidy, which the November, 1971, report to Congress classified together as output-related mechanisms. Vehicle-miles are clearly a

MECHANISMS RELATED TO CAPITAL COST

	Subsidy would pay total fixed costs			Subsidy would pay cost of depreciation			Subsidy would pay interest on debt			Subsidy would pay cost of maintenance		
Total subsidy*	$109.1			$68.8			$40.4			$150.3		
Type of firm	Bus	Multi Mode	Commuter Rail	Bus	Multi Mode	Commuter Rail	Bus	Multi Mode	Commuter Rail	Bus	Multi Mode	Commuter Rail
Subsidy*	$35.1	$57.5	$16.5	$26.3	$29.5	$13.0	$9.0	$28.0	$3.5	$46.4	$80.0	$23.9
Initial deficit*	$15.2	$166.5	$59.5	$15.2	$166.5	$59.5	$15.2	$166.5	$59.5	$11.2	$158.0	$59.5
Deficit after subsidy*	$6.7	$139.9	$47.6	$7.9	$159.8	$49.4	$12.1	$143.4	$57.3	$3.1	$84.5	$35.4
Per cent decrease in deficit	56	16	20	48	4	17	20	14	4	72	47	41
Initial surplus*	$10.6	$3.4	$1.8	$10.6	$3.4	$1.8	$10.6	$3.4	$1.8	$7.6	—	$1.8
Per cent increase in surplus	252	870	225	180	637	154	56	143	71	503	—	68
Per cent of subsidy used to:												
reduce deficits	24	48	72	28	25	76	34	82	64	17	92	87
increase surpluses	76	52	28	72	75	24	66	18	36	83	8	13
Number of firms:												
in sample	97	12	15	97	12	15	97	12	15	78	9	15
receiving subsidy	93	11	13	91	10	13	73	8	9	78	9	14
originally with deficit	47	8	14	47	8	14	47	8	14	37	7	14
moved out of deficit after subsidy	22	3	2	19	3	2	9	1	0	23	2	1

measure of output, but passengers seem to be more a measure of demand; hence the table format has been modified slightly from that of the original report.

The figures indicate the probable outcomes of the various mechanisms; the percentages are probably more revealing than the absolute amounts. However, when one recalls that the firms represented serve about 85 percent of total transit ridership, even the absolute amounts may be fairly accurate.

The "pay maintenance cost" strategy seems relatively appealing in terms of its efficiency. That is, it seems to apply most of the subsidy where the deficits are greatest rather than adding to profits of firms already operating at a profit. Unfortunately, the mechanism does not go far enough—it does not cover all the deficits and it leaves too many firms still in the red.

The operating-cost-based strategies have two defects. For bus-only firms, any program level high enough to move deficit firms to a breakeven or profit position also results in very high windfalls to profitable firms. For multi-mode and rail properties, the capital-cost based strategies appear more effective.

Output-based strategies were strongly advocated by industry spokesmen. On the positive side, a vehicle-mile formula is administratively simple; vehicle-miles are a much better measure of levels of service than are costs and other input measures. By offering a bonus for mileage operated on new routes, such a formula could encourage innovation. On the negative side, such a formula would strongly resemble a cost-based subsidy for bus-only firms because of the high correlation between vehicle-miles operated and total costs. An output formula therefore shares the disadvantages of an operating-cost-based formula for bus-only firms. For multi-mode firms, the proposed 5¢/vehicle-mile level appears inadequate to insure survival for some of the more problem-ridden firms.

A demand-based formula (for example, 5¢ per passenger) might at some level be sufficient to insure firm survival. Note, however, that the program cost of such a formula is well above that for virtually every other mechanism studied (the one exception is the 20 percent-of-total-cost formula) and would have required, for the nation as a whole, a $300 million program in 1969 (based on an estimated six billion riders during that year).

Problems with the demand-based formula, however, are substantial. The result of applying the formula is extremely ambiguous. One firm may view it as a device to keep it in business; another may view it as a stimulus to seek new ways of serving the public. The firm that chooses to take the subsidy merely as assurance that it should stay in business is, in effect, being rewarded for doing in the future just what it did in the past. It is not encouraged to seek answers for its problems. On the other hand, a firm that takes the subsidy formula as a signal that it should go out and actively seek new passengers may do so in several ways, and the formula itself gives no direction. A firm that finds it easiest to develop new patronage in middle and high-income suburbs may certainly do so under the subsidy formula; this outcome would be perverse in welfare terms. The firm's captive riders—those with low income and no access to an automobile—could be left to fend for themselves, their only consolation a slow-down in the upward trend of fares.

MECHANISMS RELATED TO OPERATING COST

Subsidy would pay 5 per cent of total cost			Subsidy would pay 20 per cent of total cost			Subsidy would pay 5 per cent of variable cost		
$89.9			$354.6			$82.1		
Bus	Multi Mode	Commuter Rail	Bus	Multi Mode	Commuter Rail	Bus	Multi Mode	Commuter Rail
$20.9	$50.6	$17.4	$87.2	$197.9	$69.5	$20.3	$46.0	$15.8
$15.2	$166.5	$94.8	$17.7	$158.1	$94.8	$17.7	$166.5	$94.8
$8.4	$131.4	$77.7	$11.6	$31.5	$32.2	$10.8	$133.2	$80.7
45	21	18	91	71	66	39	20	15
$10.6	$3.4	$1.8	$14.7	—	$1.8	$14.9	$3.4	$1.8
134	450	53	483	—	214	89	381	38
32	69	89	18	64	85	34	71	92
68	31	11	82	36	15	66	29	8
97	12	16	100	9	16	103	12	16
97	12	16	100	9	16	103	12	16
47	8	15	49	7	15	50	8	15
19	3	1	37	3	3	21	3	1

The potential results of two mechanisms for computing subsidies for mass transit are analyzed in this table, based on data published by the U.S. Department of Transportation in 1971. The four columns at the left (on facing page) show the use of four indices related to the capital costs of mass transit systems—fixed costs, depreciation, interest on debt, and maintenance; the right columns (this page) show the results of three possible indices related to operating cost. *All dollar amounts are given in millions.

Federal vs. Local Roles

Apart from the administrative issue, but related to it, is the broader question of the appropriate role of the federal government in the entire mass transit area. Local transit is basically a local issue. It is difficult to argue for federal involvement in transit on the grounds that the national interest is involved, in the same way it might be in national defense or health care for the aged. A somewhat more palatable argument is that other federal programs have succeeded in distorting local priorities to the point that the transit subsidy program is needed to right the balance. (The counter to that argument, of course, is that the transit program may induce distortions elsewhere, creating a need for yet another program!)

In our discussion of the administrative problem, we listed five criteria for subsidies. It was suggested that any one subsidy mechanism could not satisfy all at once, but when treated at the local level, some resolution of the problem is possible. If a locality chooses to keep its transit firm in operation at all costs while another chooses efficiency, so be it. There is no standard pattern of decision-making in all cities, as would almost surely occur in a federal program.

There is a further issue: in terms of our fundamental concept of the federal system of government, there are real problems in allowing transit firms that feel they are not getting a "fair deal" in their localities to appeal to the federal government to overturn local spending priorities. This matter of altering local resource allocations is, of course, common to all categorical grant programs. But it has been argued that there is a significant potential for undermining the hierarchical structure of government by continuing and strengthening the trend of federal involvement in program areas whose externalities are not clearly national in scope.

The counter-argument is that government has traditionally been a "defender of the underdog." The transit rider—indeed, the transit system itself—plays the underdog role, and partly because of federal aid to other modes. There is ample precedent in U.S. history for an appeal to higher levels of government where remedies for inequity are not forthcoming at lower levels. But there is also a tradition that local appeals should be exhausted before the case is taken to higher levels.

The philosophy of federal involvement, however, is somewhat less important than our experience with it. As a pragmatic matter, the federal track record in categorical grant programs is simply not all that good. There is strong intuitive appeal to a revenue-sharing type of approach that permits localities to allocate resources according to their own priorities rather than according to a set of priorities federally determined for all cities simultaneously. This approach has recently been given added impetus by Congressional approval of a general revenue-sharing bill.

Passage of a special transportation revenue-sharing measure has appeal. For one thing, those wishing to use Highway Trust Fund money for transit purposes may gain easier access to the funds if their use is still limited to transportation purposes. Regardless of the sources of funds, however, there is merit to permitting cities to choose more freely how their federal dollars are divided among highway and transit investments and operating costs. While categorical grant programs carry the implication that localities are not capable of

A third mechanism for computing subsidies for mass transit is related to output—either the number of vehicle-miles of service provided or the number of passengers served. This table shows the effect of a 5-cent subsidy computed on these data for over 100 mass transit firms, of which approximately half were operating with deficits when the figures were assembled in 1969; more than half these firms would have been lifted out of their deficit positions by either of the proposed subsidies. (Data: U.S. Department of Transportation)

	Subsidy would pay 5¢ per vehicle-mile (all dollar amounts are in millions)			Subsidy would pay 5¢ per passenger (all dollar amounts are in millions)		
Total subsidy	$75.0			$235.3		
	Bus	Multi-modal	Commuter rail figures not available	Bus	Multi-modal	Commuter rail
Subsidy	$24.5	$40.5		$80.9	$140.9	$12.5
Initial deficit	$15.2	$166.5		$14.5	$163.7	$91.8
Deficit after subsidy	$7.4	$138.6		$2.6	$52.4	$81.3
Per cent decrease in deficit	51	17		82	68	12
Initial surplus	$10.6	$1.1		$10.2	$0.2	$1.8
Per cent increase in surplus	159	1184		674	15,800	125
Per cent of subsidy used to:						
reduce deficits	32	69		15	80	82
increase surpluses	68	31		85	20	18
Number of firms:						
in sample	96	11		92	9	16
receiving subsidy	96	11		92	9	16
originally with deficit	47	8		44	7	15
moved out of deficit after subsidy	21	3		31	2	1

making wise resource-allocation decisions, the revenue-sharing approach has the virtues of assuming that localities can decide wisely (or at least should be permitted to make their own mistakes) and admitting that the federal government cannot prescribe one medicine to cure all cities' transit ills.

The Symptoms and the Problems

We said earlier that transit deficits were a symptom, not a problem. Later we argued that eliminating deficits would not cure the problem, although it might enable a number of transit firms to remain in business. The question remains: What is the problem?

Any discussion of "the urban transportation problem" that occupies a few pages in a magazine is of necessity a superficial treatment of a complex issue. That said, let me concentrate on two facets of "the problem" which lead to some suggestions for an appropriate federal role in transit.

There are really *two* urban transportation problems. One is congestion, the other mobility. Congestion has received the lion's share of attention—and money—until the past two or three years. It is primarily a big-city phenomenon, and sometimes the cure is massive investments in public transit instead of highways.

Mobility has just recently begun to receive the attention it deserves. If congestion is caused by autos, mobility problems are caused by the lack of autos. People without access to automobiles are consistently denied access to many of the activity options offered to the more fortunate, mobile members of an urban society. As urban economic activity patterns have changed, with the traditional downtown areas growing relatively less important, people's travel demands have changed. But public transit services have not changed accordingly. To a large extent, transit today serves the same subset of destinations as it did just prior to World War II. (There are, of course, a few notable exceptions.) It fol-

lows that preserving existing transit service in cities will not automatically improve mobility of people, any more than providing more highways will achieve the same result.

In curing the congestion problem, the issue is primarily resource allocation in the transportation sector. Cities must decide how resources are to be allocated to transportation in general, and how they are to be divided among the various modes. A revenue-sharing approach has a great deal of appeal in this context. If a city were allotted a stated sum of money to be spent on transportation, but permitted to decide how to allocate that sum between modes, one would expect the local decision to be at least as rational as any that might come from a series of categorical grants from the federal level. If one city chose to spend its whole allotment on highways and parking garages while another spent its sum on subsidized public transportation to downtown areas, well and good. To the extent that relief of congestion is a program goal, anything short of revenue-sharing will in all likelihood turn out to be a rather cumbersome form of revenue-sharing anyway, because federal dollars available only for use in one program area still free other funds, which can be re-allocated elsewhere.

The mobility problem is somewhat less tractable. It seems fairly clear that today's public transportation service is not responsive to demand, except perhaps in the special case of the journey-to-work-downtown. It is not clear just what kind of service *would* respond to current travel demands. Unfortunately, to mount a research program to determine the travel needs of currently unserved groups would be well beyond the ability of any single transit firm. Nor would the returns justify the expenditures by a single firm. The national benefits of such a program, however, would far exceed the local ones.

A Prescription

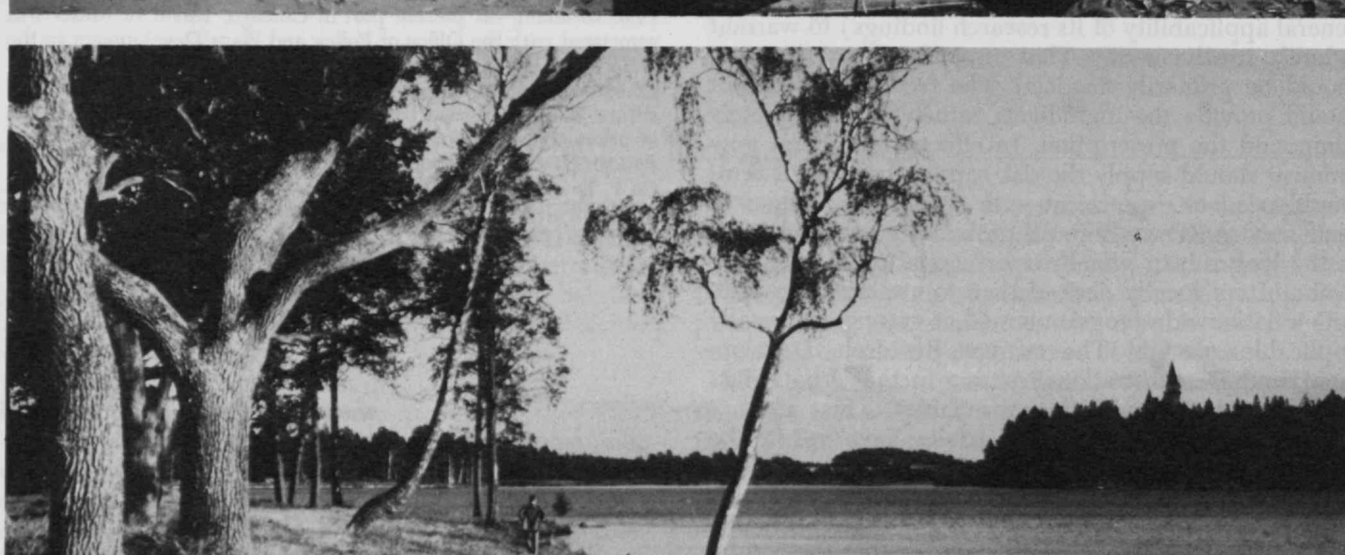
A program is needed to test service innovations. Such a program appears to have sufficient externalities (in general applicability of its research findings) to warrant federal involvement. That involvement, however, should be primarily financial. The federal government should provide the ingredients rather than completely compound the prescription. In effect, the federal government should supply the risk capital that transit firms would need to experiment with significant changes in their service. It would in all probability prove cheaper in the long run to permit experimentation in each city to the extent locally desired than to attempt to coordinate a nationwide program aimed at getting universally applicable answers. The current Research, Development, and Demonstration Program in the Urban Mass Transportation Administration includes a first attempt at local experimentation. Its results have yet to be widely transferred throughout the industry, but much has been learned about the problems of running such experiments. It is now time to build on that knowledge and attempt a new set of experiments, carefully planned, with specific goals and criteria by which their success or failure can be measured.

It should be possible, for example, for a city to look at a service improvement program after it has operated for two or three years (with the federal government underwriting the costs of the experiment) and decide for itself whether the program could be self-supporting in whole or in part and therefore ought to be made permanent; whether it would probably not be self-supporting but was socially desirable and therefore worthy of public subsidy at the local level; or whether it was neither capable of self-support nor sufficiently desirable to be subsidized.

Transit firms and local public transport agencies need the kinds of answers these experiments could provide if they are ever to learn how to make their service more responsive to changing demands. Federal funding of service experiments appears as a productive way of encouraging needed structural changes in the transit industry. Otherwise, the federal government will find itself in the position of supporting an industry which has failed the market test and which cannot even rally enough local support, in competition with other claims on local revenue sources, to insure its continuance. Granted that it is necessary to find ways of insuring continued public support for urban transportation if it is to survive, but it is equally necessary for urban transportation to meet the public's travel needs if it is to be worthy of support.

Prior to taking his present post in Chicago, **David R. Miller** was associated with the Office of Policy and Plans Development in the U.S. Department of Transportation; earlier he was Executive Director of the Syracuse University Urban Transportation Institute. He has a broad background of research in the economics of urban transportation and is the editor of *Urban Transportation Policy: New Perspectives* (forthcoming from D. C. Heath and Co.) Dr. Miller studied business administration at Temple University (B. S. 1962) and economics at Northwestern (M. A. 1965, Ph.D. 1967).

The town of Växjö in southern Sweden stopped pouring sewage into Lake Trummen in 1958 when it became obvious that the 1 km.^{2} body was overexploited. The upper photograph shows the unrecovered lake 11 years later—no oxygen, no fish, no underwater vegetation, little human use. The problem mainly was one of a rapidly increasing black muddy sediment fed by decaying plankton. Starting in 1970 the sediment was sucked out and deposited into settling ponds; runoff water was freed of phosphorus and returned to the lake. Lake Trummen is now in good health (lower photograph) and a recreational asset.



Sven Björk
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Each lake receives a tailor-made limnological treatment in an innovative program that has developed some promising techniques.

Restoring Lakes in Sweden

Since lake restoration research is a very young field, ecologists need opportunities to test their ideas, to apply their theories in nature, to provide concrete examples of ecologically sound methods of tackling the problems created in lake ecosystems by man.

However, responsibility for the restoration of lakes does not rest solely with ecologists. A cooperative effort with public administrators, politicians and technicians is necessary.

There are very few cases on record, to date, where these interests have joined forces to save a damaged lake.

This article presents four lake restoration projects, three in Sweden and one in Tunisia, that prove such cooperation is possible. The great interest displayed by the concerned governments in initiating projects such as these to improve the human environment is most encouraging. Two of the projects are completed, and work is progressing on the other two. Each project is an educational experience and provides further knowledge of the structure and function of lake ecosystems.

The four projects were undertaken by a team of limnologists at the University of Lund in Sweden as part of a lake restoration program that has been going on for several years. Now that the initial phase of the program is finished, news of the ideas and methodology is travelling quickly to other parts of the world, and due to a lack of funds for nonroutine limnologic investigations in Sweden, trained limnologists will probably follow.

The aims of the lake restoration research program at the University of Lund can be summarized as follows:

—To obtain methods of solving some of the severe environmental problems that Man has created.

—To restore certain lakes judged to be of high environmental value.

—To train limnologists and other ecologists so that they are capable of solving practical problems in applied water management.

—To contribute additional knowledge to theoretical ecology.

As each water is unique, each one must be investigated and given a tailor-made limnological treatment. It must be stressed that it is impossible to establish a standardized treatment. The lakes investigated in this program represent a wide variety of conditions.

The three Swedish lakes included in the program are of different types: shallow Lake Trummen and deep Järla Lake—both old receivers of sewage and industrial waste water—and shallow Hornborga Lake, where the water level had been drastically lowered. Thus three different sets of methods had to be worked out to correct the balance of the three different lake ecosystems. This meant that, among other things, the equilibrium between production and mineralization had to be restored.

A total of about 20 research workers from the Institutes of Limnology, Microbiology, Plant Ecology, Animal Ecology, and Quaternary Geology have been active in the project, and there has been close cooperation with technological experts.

The Hornborga Lake project began in the late fall of 1967, the Lake Trummen project in the late winter of 1968, and the Järla Lake project in the late winter of 1969. The former is still in progress, and the latter two have been completed.

Some of the knowledge gained from the Swedish experiment is now being applied in a project to restore the Lake of Tunis in Tunisia. Plans for this restoration are being formulated under the auspices of the Tunisian Government, Tunis city administrators, and fishery administrators. These authorities are anxious to see the lake transformed from the environmental mess it is today to the environmental asset it can be tomorrow. This can be a fairly simple operation if carried out in the ecologically correct way. The Tunisia project is described later in this article, following a presentation of the Swedish pilot projects.

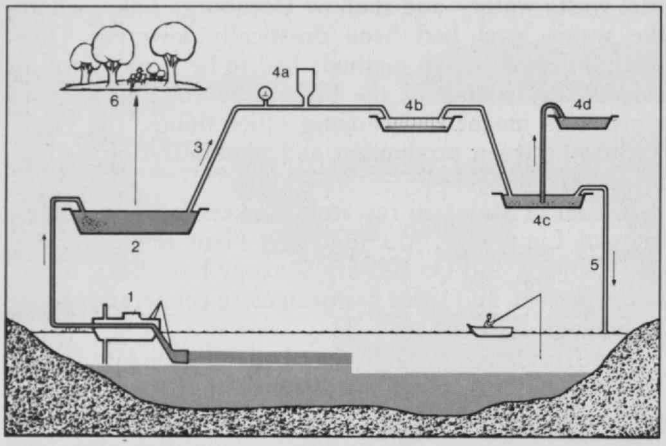
Lake Trummen

The inland town of Växjö (ca. 60,000 inhabitants) is surrounded by lakes. Of these, Lake Trummen and Växjö Lake became the first recipients of the town's sewage. When these eventually became overexploited, the waste water was diverted to another, South Bergunda Lake. For the past 20 years or so, the sewage has gone through a two-step treatment. A third step, treatment with aluminum sulfate was added in 1972. At this time, however, South Bergunda Lake is also overexploited. Nearby North Bergunda Lake is therefore being considered as the potential fourth recipient of Växjö's waste water.

Helga Lake, which lies north of Växjö, became polluted by waste water from a paper pulp plant and is blacklisted because of the high mercury content there.

Originially, Trummen, Växjö and South Bergunda were low-productivity lakes, but the inflow of waste water eventually converted them into water bodies

Lake Trummen was virtually dead when the sewage inflow was cut off. It did not recover for 12 years. Then a restoration project, based on removal of sedimentary ooze, brought the lake dramatically to life again.



Lake Trummen's tailor-made treatment: (1) suction dredger designed to operate with minimal turbidity and mixing; (2) settling pond; (3) runoff water; (4) precipitation of phosphorus and suspended matter with aluminum sulfate; [(4a) automatic dosage, (4b) aeration, (4c) sedimentation, (4d) sludge pond], and (5) clarified runoff water. (6) The dried sediment is used as fertilizer for parks and lawns.

containing concentrated nutrient solutions and maintaining an enormous growth of algae in the summer.

Lake Trummen (1 km.^{2}, maximum depth 2 m. until 1969) was well fed with sewage, especially from 1936 to 1958. From 1941 to 1957, the lake received waste water from a flax factory. Prior to that, only small quantities of waste water were discharged into the lake. The lake was utilized as a water supply source, at least to some degree, until the 1920s. During that time the bathing places were frequently utilized.

From a water conservationist's point of view, it is a remarkable and important fact that Lake Trummen did not recover after the inflow of waste water was cut off in 1957—1958. This meant that the lake maintained the characteristics of an overexploited recipient during the 1960s. In the soup of blue-green algae, the summer transparency in 1969 was only about 20 cm., reeds and water lilies spread and the total oxygen deficiency in the winter killed off the fish. There was no underwater vegetation at all.

Substantial investments are made in sewage treatment plants in order to improve the environment. In Sweden, about 300 million Swedish kronor (ca. US $60 million) are invested per year in plants (not including pipes to these). During periods with high unemployment the investments are much larger.

It is common knowledge that waste water treatment methods are still fairly stereotyped, and that very few plants use original combinations of methods specially tailored to the ecosystem of the specific receiving body of water. The efficiency of the treatment is commonly expressed in relation to the raw sewage.

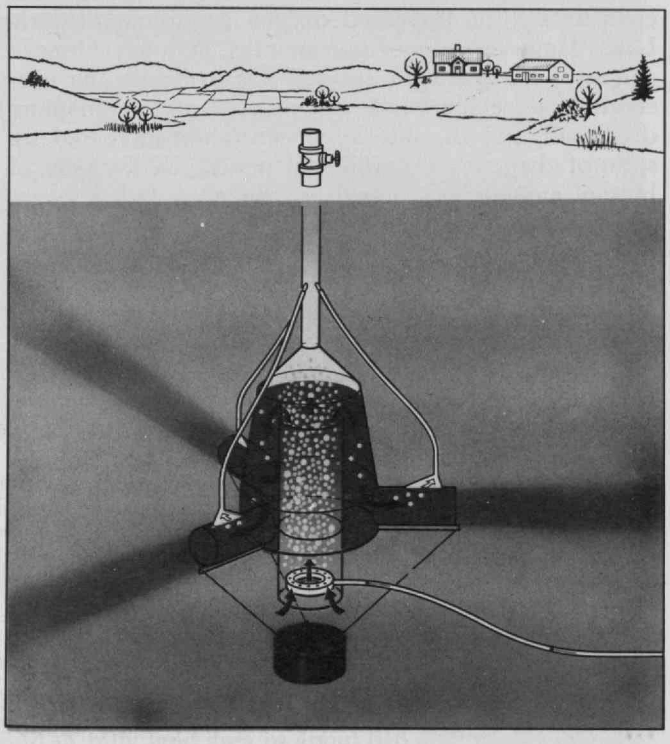
When dealing with a receiving lake's ecosystem, single-factor data are given, e.g., supply of phosphorus or nitrogen per ha./yr. Figures such as these can be evaluated in agriculture when fertilizers containing a few elements are added to monocultures growing in extremely well-known soils. However, no two lake ecosystems are alike, neither with respect to environment nor to organism communities. Furthermore, the lake ecosystems undergo successive changes as they undergo exploitation, which means that this kind of evaluation is hardly relevant to the measuring of the loading of lakes.

In treatment plants as well as in lakes, physical and chemical parameters are easily recorded automatically. Within the biological sector we must confess that we have great difficulties, even in identifying the organisms chiefly involved in the treatment process and responsible for the variations in the recipients' ecosystems. An enormous investment is necessary if we are to have, decades from now, enough trained limnologists within the biological sector, microbiologists, planktonologists, etc.

The fact that there are great variations in nature means there are also great variations in the influence of different treatment plants on different lakes. Some receiver lakes are exploited to the point where the damage is irreversible: even when the source of pollution is cut off, the lake cannot recover on its own. Other exploited lakes have the capacity for self-recovery, at least to some extent.

In the case of Lake Trummen the damage was irreversible.

Just before Trummen became a recipient of waste water, the sediment growth rate was 0.4 mm./yr. The onset of pollution and the consequences thereof caused an increase in the growth rate to 8 mm./yr. The difference in the quality of the two sediments is striking. During the lake's recipient period, the accumulation per m.^{2} of phosphorus was up to 20 times higher and the accumulation of zinc was up to 65 times higher than before the waste waters started pouring in.



Aerating the oxygen-depleted lower levels of 23-meter-deep Järla Lake without disturbing thermal stratification. The compressed-air oxygenation (250 kg./day) is done internally in the submerged unit so that bubble-free water may be dispersed over a large bottom area. The photograph shows the installation of a specially developed hypolimnio aerator, which restored the oxygen level of the deep waters without causing eutrophaction at the upper levels.

The irreversible situation in Lake Trummen was due to the deposition of the loose black "cultural layer" covering the well-consolidated brown sediment of the pre-recipient years. The black mud layer was from 0.2 mm. to 0.4 m. thick, and the nutrient leakage from this layer caused the high productivity in the spring and summer. Plankton and macroscopic plants grew, died, settled and decayed, maintaining the rapid growth rate of the sediment and supplying it with releaseable nutrients.

The limnological plan for the restoration of Lake Trummen was focused on the sediment problem. It was decided that the black cultural mud had to be pumped from the lake up into settling ponds on land. From these, the run-off water would go through a simple treatment plant for phosphorus removal before being discharged back into the lake.

The project was carried out with very stimulating cooperation between the ecologists, town authorities and technological experts. For the sediment-removal part of the project, a suction-dredging method was used. The limnologists requested a nozzle which would make it possible to suck in the sediment without making the lake water turbid and with very little mixing of lake water. The engineers of the Swedish company Skanska Cementgjuteriet constructed this nozzle.

In 1970 about 0.5 m. of sediment was removed, and in 1971 another 0.5 m. Altogether about 600,000 m.^{3} of mud and 300,000 m.^{3} of lake water were pumped to the settling ponds. The ponds were constructed in an arable land area from which the topsoil had first been removed, exposing a poor moraine suitable for pond dikes. The sediment pumping ended in October 1971. The dried sediment is now being used as a fertilizer for lawns and parks in the rapidly growing town of Växjö.

The run-off water from the settling ponds was a mixture of lake and interstitial (sediment) water. Its high fertilizing effect was checked by means of bio-assay with algae. The total phosphorus content in the water in Trummen before the restoration was ca. 600 μg/1 in the summer, and in the untreated run-off water from the settling ponds, a further increase was brought about by the addition of interstitial water. However, aluminum sulfate was used for precipitation of suspended matter and phosphorus, and thus in the treated water returned to the lake the total phosphorus content was only about 30 μg/1.

The littoral zone of Lake Trummen is fairly rich in stones and boulders. In the landward part, the dense

vegetation growing in sediments overlying the stoney bottom had to be removed by a dragline. The elimination of the vegetation exposed the original shoreline to view. In 1972, the first year after the restoration, a distinct rinsing of the shores [took] place, thanks to the revived water movements. Until the sedimentation limit has stabilized, a detritus turbidity will be noticeable in the water. The invasion of underwater vegetation and bottom fauna will help to keep the detritus particles confined to the bottom.

Follow-up investigations in Lake Trummen will continue until the summer of 1980. Information will be collected on water and sediment chemistry, phytoplankton, macrophytes, zooplankton, bottom fauna and fish populations.

As was foreseen, the changes in Trummen's ecosystem have been dramatic. The transparency has increased but [was], in 1972, still limited by plankton and is highly dependent on the amount of detritus whirled up by the wind, especially from the littoral zone. The phosphorus content has decreased, as has the nitrogen content. During the late winter period which had in the past been the critical time, the oxygen conditions were excellent after the black sediment had been removed. The heavy waterbloom of *Microcystis spp.* (blue-green algae) disappeared, while *Pediastrum spp.* (green algae) and *Anabaena flos aquae* (blue-green alga) were the characteristic summer plankters of 1971 and 1972, respectively.

Lake Trummen is now accessible for fishing and bathing, and it can be considered to be a valuable recreational asset.

The total cost of bringing Lake Trummen back to health was Sw. kronor 2.5 million (U.S. $500,000). The cost of adding the third step to the Växjö treatment plant was Sw. kronor 20 million (U.S. $4 million).

Now that it has been brought back to health, Lake Trummen is being attacked from another angle. A proposal to build a new motorway across the lake and along the southern shore has been made. None other than the National Swedish Road Administration would be responsible for the realization. It is a remarkably short-sighted proposal, an example of the kind of "progress" envisaged by the forces of exploitation. Another motorway is already being built close to the western shore. This new encroachment on the Lake Trummen area would, of course, be an irremediable mistake. The lake has been restored, yes. But if Trummen is to be framed in by motorways, one could well ask, restored for what? And for whom?

Järla Lake

Situated near Stockholm, Järla Lake has an area of 1 km.^{2}, is 23 m. deep at its deepest point, and has a distinct thermal stratification in the summer. It is an old recipient for sewage and industrial waste water. Before the restoration project, the oxygen content in the lower water layers was reduced to zero during stagnation periods.

Although it is possible to increase the oxygen content of some lakes by means of artificial total circulation during the natural stagnation periods, this method was not advisable in the case of Järla Lake. Artificial total circulation would have brought about the transport of nutrients from the bottom water layer and their dispersal in the illuminated superficial water layer—thus increasing the productivity—and the cultural sediments would have been warmed up, bringing about an increased consumption of oxygen.

The goal of the Järla Lake project was to increase the oxygen content of the lower water layers in a limnologically correct way, i.e. without disturbing the thermal stratification. A collaboration between limnologists and technological experts from the Central Laboratory of Physics at the Atlas Copco Company resulted in the ingenious technical solution shown on p. 55.

In brief, this equipment now makes it possible to increase the oxygen content in deep recipients to the desired degree. In a lake of the Järla type, the earlier anaerobic water layers could easily to kept at an oxygen level of, say, 7 mg./1.

Because of lack of funds, it has not been possible to carry out long-term studies of limnological changes accompanying the improved oxygen conditions of Järla Lake. However, after three months' aeration (June—August), the sediment surface was oxidized, the concentrations of phosphate phosphorus and ammonium decreased, and the nitrate concentration increased. In spite of the short experimental period, an invasion of bottom animals was hoped for, but they failed to appear. A search conducted to determine the causes of this and the consequences of the aeration of the sediment led to the discovery that the cultural sediment layer was partly impregnated by oil, which made it impossible for certain organisms to survive.

Experiments are now being carried out in West Germany in which inert phosphate-adsorbing substances are added in connection with the aeration.

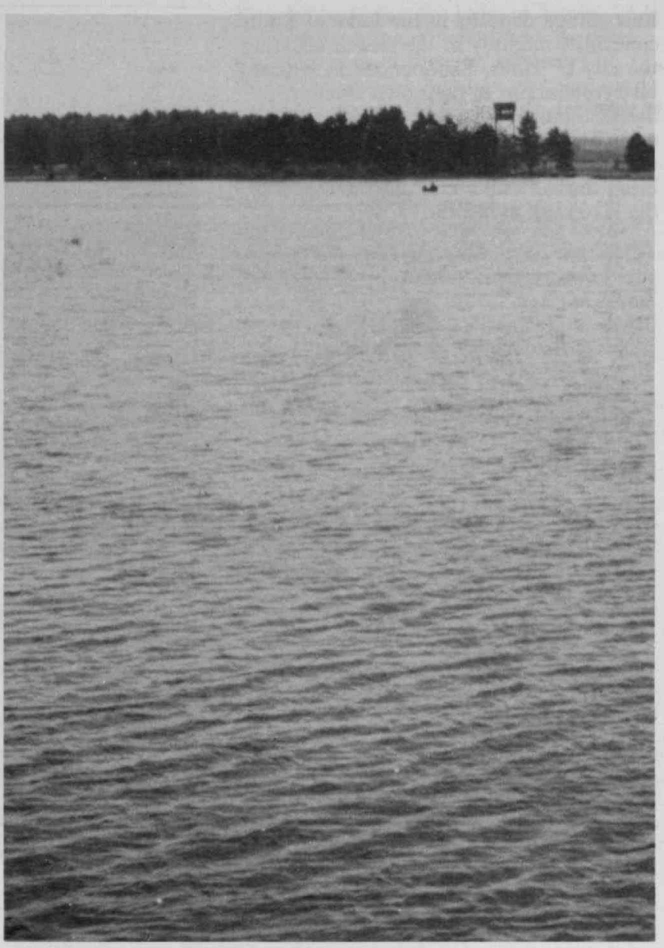
In Sweden, the effect of the so-called "bubble-method" has been checked in a 7 m.-deep lake in which a thin layer of bottom water was depleted of oxygen during calm periods. In this lake the proportions between the volumes of water with and without oxygen made it possible to use artificial total circulation. With this method compressed air bubbles out from plastic hoses distributed in a rib pattern in the deepest part of the lake. Anaerobic conditions can thus be avoided. As soon as the oxygen content of the lake starts to decrease, the compressor is started and operates until the oxygen deficiency is eliminated.

Aeration and bubbling are two ways of making recipients more effective and for speeding up the recovery process in old recipients. Irreversible damage can in this way be prevented until a modern treatment plant is built.

Hornborga Lake

Hornborga Lake is a shallow, drained lake. Until man interfered with the well-organized system of components that functioned within this lake, it maintained a rather high degree of productivity without suffering from rapid aging. That is quite remarkable for a lake of this size (30 km.^{2}) and shallowness (3 m. at the deepest point). Most of the lake was much shallower. A constellation of such factors as rapid water renewal, well-situated inlets and outlets, strong water movements, and strong ice movements prevented the lake from becoming overgrown and provided a good system for transporting matter from the lake.

Since 1802 the lake has been lowered five times in attempts to obtain arable land. The last big failure, in 1932—1933, resulted in a bottom that was drained in



Sweden's 30 km.[2] Hornborga Lake was lowered five times in futile attempts to gain arable land, the last in 1933. The result was a large area covered with reeds, sedge, and willow bushes. Restoration work was started in 1968 using amphibious and floating machinery for mowing, cutting, harvesting, and cultivating. The goal for the restoration was to transform 11 km.[2] of reed area into open water and to keep 18 km.[2] sedge-covered as a substitute for the original marshy areas. By 1970 the new open water area was becoming repopulated with desirable underwater vegetation and bottom fauna.

the summer, and which consisted largely of calcareous mud. A hilly land area of about 616 km.[2] drains into the lake. This area needs the big reservoir Hornborga Lake to catch rainwater and melted snow that rush down the hills to the plain below.

From a nature conservancy point of view, the lake had a very high value before it was lowered, especially as a nesting site and resting place for waterfowl. After the last lowering, the lake ecosystem's structure and function were definitely destroyed. Monocultures of *Phragmites communis* (common reed), *Carex acuta* (sedge) and *Salix spp.* (willow bushes) crept in and nearly covered the lake area until 1967.

The National Swedish Environment Protection Board, after being ordered by the Government to investigate the possibilities of restoring Hornborga to the status of a waterfowl lake, organized a broad study of the complex of man-made problems concerning the lake. One year of limnological studies made it quite clear—theoretically—that the lake could still be restored. Large-scale field experiments were begun in 1968 to work out practical methods of correcting the irreversible damage. This was made possible because of the cooperation between the National Environment Protection Board, the National Labour Market Board, the National Board of Forestry, Seiga Harvester Co. (manufacturer of amphibious machines), and the Institute of Limnology at Lund.

As the water level had been lowered, emergent vegetation had invaded the colonizable areas and the upper sediment layer had become interwoven by roots. With the two plant species *Carex acuta* and *Phragmites communis* covering the main area of the southern and northern parts of the lake, respectively, the sedge had developed a thick, tough and resistant root felt. The sedge root felt posed a problem, as it was impossible to remove. However, the reed root felt could be cut by the amphibious rotor cultivators that were constructed for this project. The development of amphibious and pontoon-equipped machines for the restoration of lower lakes is continuing, and rotor cultivators strong enough to cut the sedge root felt will be constructed.

The project goal for Hornborga Lake is to transform the reed areas to open water (about 11 km.[2]) and to keep the sedge-covered part (about 18 km.[2]) for emergent vegetation as a substitute for the originally marshy areas around the lake.

The restoration plans for Hornborga Lake include a raising of the water level for a maximum depth of 1.9 m. or, even better, 2.4 m. It should only take one spring to fill the lake with water, as Hornborga Lake is flooded

Raw sludge deposits in the Lake of Tunis contribute mightily to the stench afflicting the city of Tunis. Experienced in tailoring lake restorations in their own country, Swedish limnologists and engineers are using sediment pumping, aeration, and vegetation removal techniques in a plan to bring the salty 29.5 km.^{2} northern part of the lake back to health.

every year after the melting of the snow. When the water level has been raised, the sedge root felt will float to the water surface. This well-known phenomenon is caused by the gas (mainly methane) that forms in and under the root felt, through which the gas bubbles cannot penetrate. The floating root felt will rapidly be colonized by *Phragmitis, Schoenoplectus* (bulrush) and *Carex*.

By means of amphibious excavators, it is possible to break up the monotony of the sedge-covered areas—where the root felt will float up after the water level is raised—and to create a mosaic of open water and biotopes safe for nesting and attractive to birds.

The procedure for achieving the change from production of emergent vegetation to production of submerged vegetation in the reed areas is as follows:

In the winter the dry stems are cut by amphibious harvesters and burned on the ice. In the spring the stubble mats are shortened to about 40 cm. by pontoon-equipped mowers. During the low water period in the summer and autumn, amphibious machines are again utilized, first for cutting the green shoots and then for rotor cultivating the stuble mats and root felts. The requisite time per hectare is 8—10 machine hours. Enormous masses of accumulated coarse detritus are loosened from the bottom and transported by the spring high water to the shores where they are burned in the summer.

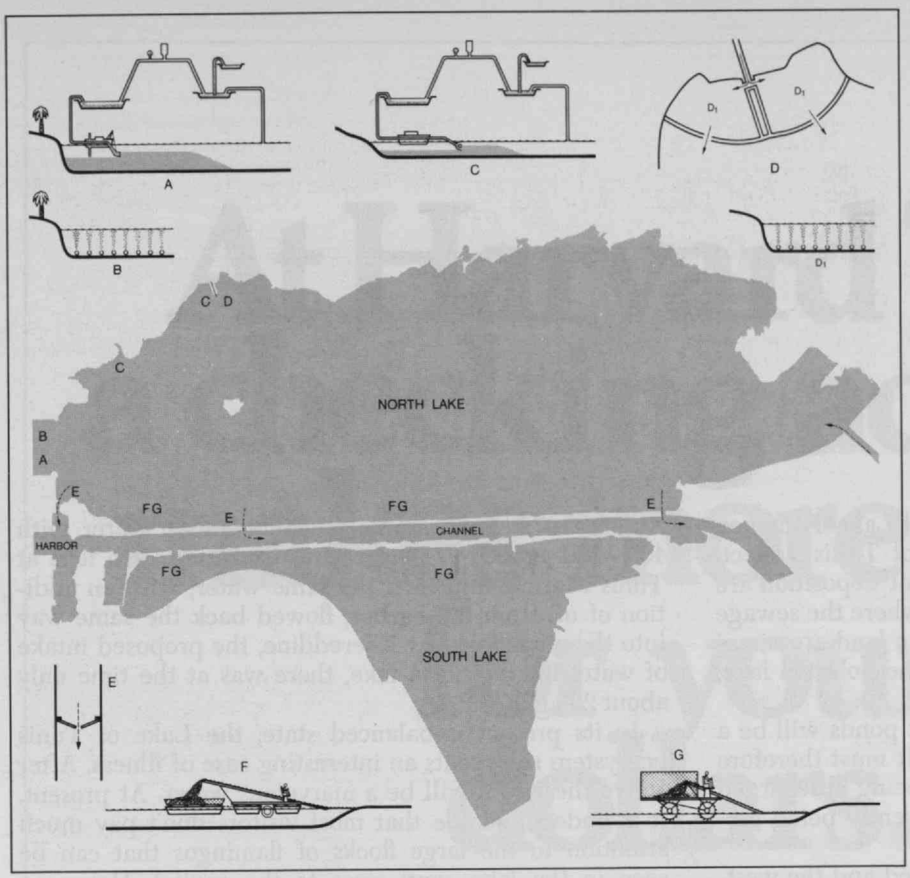
With the detritus out of the way, the consolidated mud again becomes the bottom and the reed monoculture is replaced by an underwater vegetation of *Chara* (charophytes,) *Potamogeton* (pondweeds) and *Myriophyllum* (water milfoils). A rich bottom fauna, microbenthos and periphyton is also reestablished.

Altogether, the biotope changes during the experimental period have resulted in a very obvious improvement of the waterfowl fauna. Of the nesting species, 70 per cent have increased in number. *Larus ridibundus* (the black-headed gull) increased from 5,000 to 8,500 couples, *Podiceps cristatus* (the great crested grebe) from 5 to 50 and *Aythya ferina* (the pochard) from 20 to 110 couples. These are results of the limited, experimental activity that has taken place in a small diked area of the lake where the maximum summer water depth is 80 cm. A definitive raise of the water level must include the whole lake area.

The Lake of Tunis

Experiences gained in the Swedish restoration projects—with sediment pumping, aeration and vegetation removal—were all useful in drawing up plans for the restoration of the Lake of Tunis. The city of Tunis has long suffered from the bad breath of the polluted lake. The stench is most repelling close to the population center, and it is there that the Tunisian authorities want to create an attractive environment. The planning of the Lake of Tunis restoration project has been organized and sponsored by the Tunisian Government in cooperation with the Swedish International Development Authority (S.I.D.A.) and the Institute of Limnology at Lund.

The Lake of Tunis is divided into the north and south lakes. Increasing volumes of raw sewage and increasing amounts of industrial waste water have been discharged into the north and south lakes, respectively. The north lake is the object of the restoration project dealt with here. It has an area of 29.5 km.^{2}, but contains only 27.6 million m.^{3} of water. Tunis is surrounded by



Plan for restoring the Lake of Tunis: (A) Suction-dredging of sewage sludge from the basin nearest the city; treatment of runoff water. (B) Aeration of basin until sludge is removed. (C) Sludge dredging at the Montplaisir and Cherguia sewage outlets; runoff treatment. (D) Collection of waste water from the Cherguia plant in two ponds until the outfall sludge is removed; (D_1) pond aeration. (E) Lock-controlled intake of water from the Mediterranean Sea (to right on map) into north lake, then into harbor and out to sea via the channel. (F&G) Removal of floating masses of algae using pontoon and amphibious skimmers.

very shallow, highly saline lakes. As the Lake of Tunis is connected with the Mediterranean, it does not dry up as the other lakes do. The water level, however, is dependent upon that in the sea.

The north lake is still receiving raw sewage (the westernmost part) and effluent from a treatment plant (the northwestern part). Thanks to the high salinity of the lake water (specific conductivity ranges from about 45 mS_{20} in early June to about 65 mS_{20} in early August), the coagulation and precipitation of particles is good. The sewage sludge deposits are, therefore, concentrated to restricted areas.

The self-purification capacity of the lake is still extremely good. This is apparent from the compressed zonation and steep gradients of environmental conditions and organism communities east of the outlets. In the summer the turbid zones of bacteria and phytoplankton can be very narrow in the western part, while the water in the rest of the lake is clear. In the clear area, luxuriant meadows of *Ulva* (sea lettuce) cover the bottom from shore to shore (*Enteromorpha* is also common), with the exception of the eastern part where brown algae are numerous, and there are open bottom areas that consist of pure shell gravel. Reefs of *Mercierella enigmatica* (tube worm) are common. The reefs are problematic from a hydrological point of view. However, the animals perform a filtration function, and thus play an important role in the lake's self-purification process.

The direct discharge of nutrients and the release of nutrients from the sewage sludge deposits speed up the growth of *Ulva* and other algae in the warm, shallow lake, and conditions are similar to those prevailing in a very effective algal culture. Due to the efficient photosynthesis, gas bubbles form in *Ulva* leaves, and large amounts of *Ulva* are set afloat. Thus, green mats of loosened algae periodically cover vast areas of the water surface. When the weather is warm and the water stagnant, the crop of *Ulva* and other algae decomposes and the water becomes oxygen-deficient. As the consequences of primary and secondary pollution, a nasty stench of raw sewage and hydrogen sulfide is apparent, and fish kills can occur. At times the waters of the Lake of Tunis become wine-red, and it looks as though the lake has been visited by one of the "seven plagues". This wine-red color is caused by the mass development of planktonic micro-organisms, a common phenomenon in salines and highly saline lakes in North Africa.

According to present plans, the sewage will be diverted from the north lake when a more effective treatment plant is completed. The preliminary aims of the project are to eliminate the most disturbing effects of the pollution, to break the trend toward progressively worsening conditions, and at the same time to prepare for the final restoration. In line with these aims, a working program has been presented to the concerned authorities.

The ca. 20-hectare water basin closest to the beautiful palm-lined Avenues Mohammed V and Curtelin is filled with sewage sludge and the water sparkles with gas convection. Within the areas around the sewage outlets of Montplaisir and Cherguia, the situation is about the same. In laboratory tests it was found that the release of NH_4-N is 500-900 and of PO_4-P 25—30 mg./m.^{2}/day from the sewage sludge sediment to the water. The corresponding figures from Lake Trummen were 75 and 15 mg./m.^{2}/day, respectively.

The method used in the restoration of Lake Trummen can be adopted for use in the Lake of Tunis project. Land areas perfectly suited for sediment deposition are available close to the parts of the lake where the sewage sludge is concentrated. Until now, these land areas, enveloped in the evil-smelling gas from the polluted lake, were considered to be a no-man's-land.

The run-off water from the sediment ponds will be a highly concentrated nutrient solution. It must therefore be treated in a simple plant before being discharged into the lake, and experiments are presently being carried out with different coagulents.

When the restoration project is finished and the western and northwestern parts of the lake are accessible, the dewatered sludge should be quite useful when parks and gardens are laid out in the land areas adjoining the lake.

Until the new treatment plant is finished, sewage will continue to be discharged into the lake. In order to overcome the problems presently caused by anaerobic conditions in the water nearest the population centers, and in order to keep the fertilizing effect of the sewage at a minimum during the construction period, it has been proposed that the following measures be taken:

Sewage sludge should be removed from the Esplanade basin, leaving a water depth of 2.0 m.—2.5m. "Bubble" equipment should be installed here to aerate the well-defined basin. At Montplaisir and Cherguia, the outlets in the northwest, simple ponds should be constructed in the littoral zone of the lake. These ponds should also be aerated.

Nutrients transported to the lake are efficiently concentrated in the large-leaved algae *Ulva* and *Enteromorpha.* After some alterations, the equipment designed to deal with the vegetation in Hornborga Lake should be used to skim off floating algae at different water depths in the Lake of Tunis. This activity would result in losses in nutrients and gains in oxygen for the lake.

Longer-range plans for the lake's restoration ought to include the creation of a water inflow at Khereddine and an outflow to the harbor at Tunis Marine. This should not be considered solely as a hydromechanic undertaking, but should be seen as a means of achieving a nutrient budget suitable for the lake.

By making use of short-term, wind-caused water level variations of at least 50 cm. at Tunis Marine, a large-scale export of nutrients could be secured from the lake to the harbor, to the canal and finally to the Mediterranean, bringing about self-purification. In July—August 1972, for example, nutrient-loaded water with 400—700 μg PO_4-P/l rushed out from the north lake at Tunis Marine, and then the same water, with an addition of oil from the harbor, flowed back the same way into the north lake. At Khereddine, the proposed intake of water for the north lake, there was at the time only about 20 μg PO_4-P/l.

In its present unbalanced state, the Lake of Tunis ecosystem represents an interesting case of illness. After active therapy it will be a marvelous water. At present, it is understandable that most visitors don't pay much attention to the large flocks of flamingos that can be seen in the lake, very close to the capital. However, when the lake has been restored to health, the malodorous pollution barrier will be down, and I am sure that the scene of water and flamingos set against the picturesque ruins in the island of Chekli and the sun-drenched mountains beyond will become an attraction.

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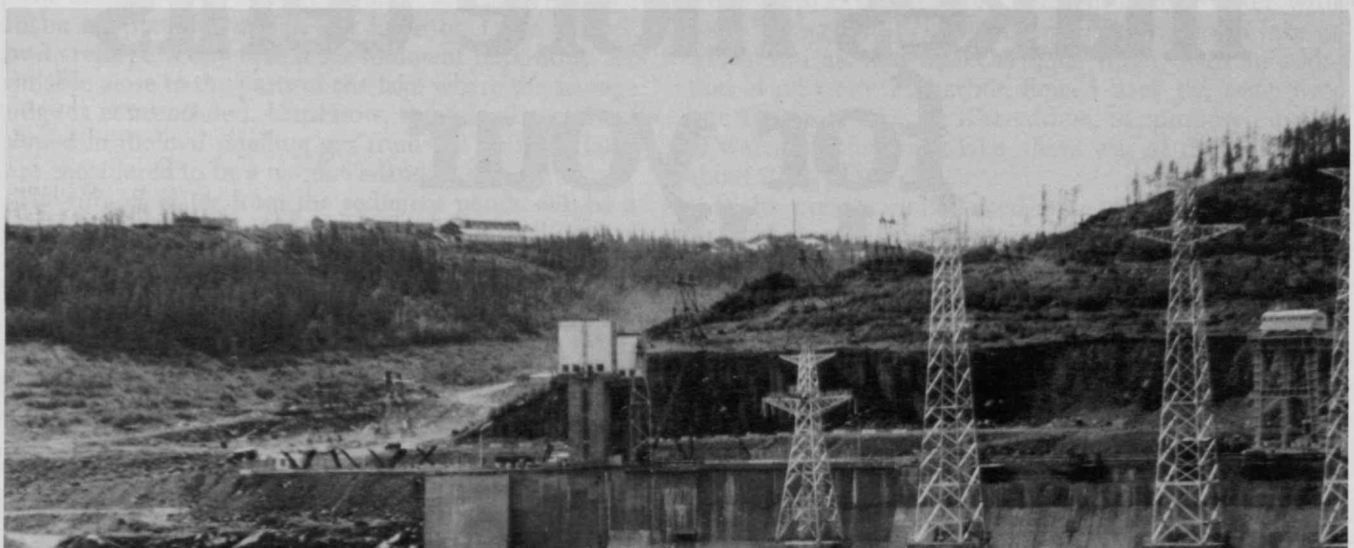


Though the generating plant in this picture looks like many others, it is in fact unique: the first high-capacity hydroelectric plant built on permafrost in the U.S.S.R. Behind it stands a 240-ft. rock-fill dam with a loam core whose reservoir extends 270 miles into the Russian arctic. Having proved that a large dam can successfully be built on permafrost, the Russians are now erecting additional generating capacity at Vilyuskaya; upon its completion, the project will provide 650,000 kw. (Photo: Douglas Kane, Institute of Water Resources, University of Alaska)

Trend of Affairs

Trends This Month

PERSPECTIVES

Multiplexing Advice for the President

Can the new part-time special assistant for science and technology give the President adequate advice at a time when the interactions of science, technology, and the total society are growing more complex? This was the implicit subject of an M.I.T. symposium last fall featuring all six former heads of the dismantled President's Science Advisory Committee (P.S.A.C.). The science advisory apparatus has had its ups and downs since President Eisenhower appointed James R. Killian, Jr. as the first such full-time special assistant. The low came early this year when President Nixon eliminated the post and asked H. Guyford Stever, Director of the National Science Foundation, to play the same role in his spare time.

Dr. Killian magnanimously suggested that the Nixon action "may be part of an evolutionary process" that will ultimately be good for American science. Said Dr. Stever, from the audience, "I have seen the phoenix burn, and I am supposed to rise from the ashes."

Military Advisors Freed of Countervailing Force

What seemed most to bother the panel—composed of Drs. Killian, Edward E. David, Jr. (President Nixon's advisor), Lee A. DuBridge (Nixon), Donald F. Hornig (Johnson), George B. Kistiakowski (Eisenhower), and Panel Chairman Jerome B. Wiesner (Kennedy)—is the sharp separation of civilian and military advice-giving. Military advice became, as of last summer, the joint responsibility of the Department of Defense and the National Security Council (N.S.C.). Can objectivity be expected from such a conglomerate of vested and political interests?

Dr. Killian reminded the panel of the D.O.D.'s technologically fanciful nuclear-powered bomber project, which took the anti-aircraft fire of three successive science advisors and many other outside critics before it was shot down. "The President (Eisenhower) looked to his science advisory committee," he said, "as a source of objective advice that he felt was not always available from . . . the three military services." At that time there was a coupling of P.S.A.C. and N.S.C., which then had a small staff and little capacity for in-depth studies of its own.

Dr. Wiesner emphasized the continuing need for a counterforce to the military monolith, a source of independent advice. "President Kennedy once told a newspaperman," he said, "that the thing that P.S.A.C. did for him was to keep the government from going all one way."

Why was the military science advisory function excised from the new N.S.F. responsibility? Basically, said Dr. David, military research and development funding is dropping off (Dr. Wiesner pointed out that it still amounts to $21 billion) and civilian needs and expenditures are growing. As Dr. Hornig put it, during the time of massive military development and the expansion of space technology following sputnik, P.S.A.C. and the President had a community of interest. That, perhaps inevitably, has changed. President Nixon has come to regard the science community as a body politic whose advice he doesn't really need, on military or civilian matters.

From the floor, Dr. Stever agreed that civilian needs, particularly energy and environmental matters, will be priority problems for decades. But, in a press conference the next day, he shrugged off a question on the need for independent advice on military research and development. He thought that the D.O.D. and N.S.C. could handle the job adequately. And, he said, the Congress will exert its independent views upon the D.O.D. budget. With a trace of flippancy, Dr. Stever reassured the reporters that if he sees anything wrong with the military use of

Former Presidential Science Advisors Killian, Kistiakowski, Wiesner, Stever (the current Advisor), Hornig, DuBridge, and David. At an M.I.T. symposium last fall, they discussed the fate of high-level advising. The consensus: concern, but not outright pessimism.

science and technology he will bring it to the attention of the President.

Getting to the President

Which raises the point of "accessibility" to the President. Dr. David managed to get about 45 minutes a week with Mr. Nixon. Dr. Wiesner and President Kennedy were friends and enjoyed talking about science and technology. President Eisenhower challenged the Killian P.S.A.C. to help him get a hold on the problem of surprise military attack. These meetings with the President, said Dr. Killian, were "extraordinary events . . . free-for-all discussions. . . .

"The Eisenhower P.S.A.C. brought into government views and analyses which led to . . . more open-minded discussion. [More important than the specific accomplishments] were the relationships of confidence and free discussion that P.S.A.C. had with the President and his associates. There was no holding back. There was no fear that someone might differ with somebody else, including the President. There was never any difficulty in seeing the President or in bringing matters before him for decision. After his retirement from the Presidency, Ike told a friend that some of his best experiences at the White House were his meetings with P.S.A.C.

"[These meetings] made it possible for a group of scientists to come to understand the President's problems, views, and goals, and to learn how to make themselves useful."

All the former advisors agreed, however, that the world is quite different than it was 20 years ago. The new issues involve much more than science and technology, said Dr. David. They involve "economics, social factors, political considerations, and most of all human sensitivities." He said there is a feeling in government that scientists are not broad enough to proffer acceptible advice outside their specialties. He thought this was why the science advisory function seemingly has been downgraded.

Said Dr. Wiesner: "We have moved from a period in which the country paid very little attention to the effects of the changing technology and its exploitation to a time when we have become much more sensitive to it. We are going to see a continuous monitoring of what is going on. And we are going to see legislation to control it. . . .

"The country can't respond to every problem raised. You have to make a prediction, watch how it is turning out, and begin to apply corrections to it slowly. This calls for sensitivity, and for a process which we have to develop."

Dr. Killian agreed that this "is one of the most challenging problems facing us now."

Thus, the question posed at the beginning of this article does not at the present time seem answerable. Perhaps it should be reworded: Should the President have yet another advisory group constituted to take a multidisciplinary approach to our national problems?—*R.S.*

The Subtle March of Tyranny

Could the managed world of George Orwell's *1984* come so subtly that Orwell's predictions are in fact fulfilled, unnoticed, even while Americans applaud the technology by which they are repressed?

The question is not rhetorical; it was Jerome B. Wiesner's form of warning to members of the International Communications Association when he opened their 1973 conference in Boston this spring.

Dr. Wiesner, President of M.I.T., said he rejoiced in his opportunity to "behave like a communications engineer again," and he proposed that, despite "impressive accomplishments, we have just begun to realize the potential of electronic communications.'

Yet with that promise comes a threat of which, thinks Dr. Wiesner, there are

two aspects:

—Each new technological advance makes "the whole fabric of society more complex," requiring that (if the system is to work effectively) "we all live and work within narrowly defined norms." We "trade individuality for efficiency," he said.

—Modern communications technology brings with it the increasing threat of surveillance—not simply the electronic eavesdropping devices which seem almost omnipresent, but the subtler surveillance implied by interconnected, massive data banks. Together, thinks Dr. Wiesner, such threats are serving to "intimidate many people, causing them to draw back from perfectly legal political and social activities. In a real sense," he said, "these activities threaten the very guarantees of the Bill of Rights," perhaps even "so markedly restrict the range of individual rights and initiatives as to menace meaningful life as we appreciate it."

But this alone is not the subtle issue. The great danger, he said, "is that such a depersonalizing state of affairs could occur without specific overt decisions, without high-level encouragement or support, and totally independent of malicious intent, . . . that we could become 'information bound' because each step in the development of an 'information tyranny' appeared to be constructive and useful."

Yet President Wiesner admitted to the dilemma. Rapid, broad-ranging communications and efficient data processing are necessary for modern society as we have created it. The question is familiar enough: Can we reap "the maximum assistance from modern technology in running a better society" and yet "keep it from dominating us."

Can new technology alone be counted on to "redress these invasions of personal autonomy"? No, thinks Dr. Wiesner, "the basic safeguards must be provided by the legislative and legal systems of this country, themselves ultimately dependent upon the integrity of men."—*J.M.*

Bring Technology Assessment to Earth

Technology assessment is the "in" thing, on the tip of everyone's tongue. Is it in fact the most important new tool for besieged public officials and decision-makers? Or is it simply a new mumbo-jumbo of the age of technology for the process of rational decision-making by weighing alternatives and their possible outcomes?

Vera T. Coates, an old hand at technology assessment as a member of George Washington University's Program of Policy Studies in Science and Technology, took the first view for members of the International City Management Association in Boston this fall. Though it is more a stranger to urban affairs than to such large national issues as nuclear power and supersonic aircraft, she said, technology assessment is most of all needed by local government.

This is because a city is "a precarious balance of forces especially vulnerable to the effects of new technology"—changes affecting job opportunities, racial balances, residential standards, and business environment. If the impact of new technology is thus most critical in a local community, so the community's greater need for effectively anticipating the effects of new technology—technology assessment.

Representative Gerald T. Horton of the Georgia Legislature was skeptical. If everything relates to everything—the usual argument for the interdisciplinary approach which is characteristic of technology assessment—how can you do anything if you don't know everything? And, he asked, what happens to a city manager who goes to his city council for money for "technology assessment" and "interdisciplinary expertise"—or to a political candidate who tells his constituents that his route to the better government and urban life they seek is through "technology assessment"?

"It's a grave political problem to make technology assessment a sexy subject in order to bring it down to earth," warned Representative Horton. Instead of fancy abstractions, they take the mystique out of it, he said. "Technology assessment is nothing but a fancy phrase used in conferences for what the hell happens if you do it—or don't do it."—*J.M.*

LIFE SCIENCES

Chemical Synthesis of Potentially Functional Gene

Another step toward the eventual goal of controlling genetic processes—a goal whose achievement holds consequences which even its advocates fear profoundly—was reported from the laboratory of Har Gobind Khorana, Sloan Professor of Biology and Chemistry at M.I.T., this fall.

The first artificial gene with the potential of functioning detectably within a living cell has been synthesized, and there has been progress toward incorporating into that gene the biological instructions it must have to fulfill its functional potential.

The synthesized gene is a replica of a gene found in the bacterium *Escherichia coli* (*E. coli*), which is a common resident of the intestines of humans and animals.

Dr. Kaniya Lal Agarwal, a member of Professor Khorana's group who reported the new achievement to the American Chemical Society in Chicago this summer, said the synthesized gene contains all the genetic information necessary for the construction of its product—a cell substance called tyrosine transfer RNA. However, portions of the gene must still be added which serve as the "start" and "stop" signals used by the cell in extracting the gene's information. Thus he termed the present achievement the "structural" gene and the goal of the team a "functional" gene.

That goal may not be very distant; there has already been considerable progress on the "stop" signal, of which 24 nucleotides have been determined (in contrast to the 126-nucleotide chain created in the *E. coli* gene itself).

With the "functional" gene achieved, it will be a short step to introduce it into *E. coli* and study the results. One of the approaches will be to alter a portion of the synthetic gene and determine the way the change affects the cell product. Thus Professor Khorana and his associates hope to begin to understand the specific functions of at least some of the 126 nucleotides in their synthetic gene.

But "human engineering," which might be achieved by controlling the genes involved in human growth and development, remains a distant prospect: human genes, in contrast to the 126-unit *E. coli* synthesis, contain millions of nucleotides each.—*J.M.*

Smoke Signals

Of the several causes of injury and death in fire, gas and smoke may be the most important—and the least understood.

Speaking to the American Chemical Society last summer, Dr. I. N. Einhorn of the University of Utah listed these most common causes of injury in fire: depletion of oxygen and addition of large amounts of carbon monoxide in the air; high air temperatures, causing searing of the lungs and tracheobronchial tree; direct exposure to flames, causing burns; combustion products—particulate matter and chemicals (some of them poisonous); and that internal adrenal reaction, panic.

Preventable death can result from any one or a combination of these. Lack of oxygen (hypoxia) is a proven cause of lassitude and extreme drowsiness. In many cases where victims are

reported as "trapped" in burning buildings, there is in fact "no visible barrier observed to easy escape"; hypoxia, possibly combined with hysteria, may have been the cause, thinks Dr. Einhorn.

The effects of combustion products—particularly smoke and gas from plastics—are even less understood.

Unidentified gases generated by burning plastics may interfere with the body's oxygen transport system, or they may affect the enzyme systems directly concerned with muscle activation and contraction. "As yet unknown mechanisms dependent upon particular combinations of noxious gases may be operating which can significantly impair peripheral motor mechanisms," Dr. Einhorn said. "Noxious gases may exert specific effects upon activation and contraction properties of skeletal muscles. Failure to respond appropriately under the stressful circumstances of a fire may depend upon loss of these peripheral motor mechanisms."

Smoke from plastics can also be poisonous in the more direct sense of the word. That area, said Dr. Einhorn, may be more important than research emphasis has indicated. Besides carbon monoxide, smokes have been found to contain sulfur dioxide, aliphic hydrocarbons, aromatic hydrocarbons, acrolein, formaldehyde, acetaldehyde, and butyraldehyde.

Although laws require that some building and aircraft plastics be treated with fireproofing solutions and flame retardants, the retardants seldom decrease the amount of smoke released. In fact, the retardants "increase the concentration and types of pyrolosis products which may be liberated during fire exposure. These products may have biological implications not previously appreciated."

Smoke of any kind contains particles which, when inhaled, can affect the lungs and tracheobronchial system. Another smoke effect, often overlooked, is the stimulation of tear flow, which may interfere with vision and cause difficulty in escape.

Studying the effects of smoke does present more problems than meet the eye. Out of 297 references to research in smoke toxicity, Dr. Einhorn found considerable variation and little correlation in results. In fact, he said that if animals are exposed to heat as well as smoke in actual fire situation, they will probably die of heat first, stymieing efforts to study smoke injury.

The answer? Dr. Einhorn has several suggestions. First is education of the public in an effort to prevent panic caused by fire exposure. The development of a realistic smoke hazard warning, along the lines of a fire alarm system, is also recommended. Since smoke is often the first sign of fire, preceding and sometimes more harmful than the fire itself, such a system would warn of a more immediate danger. Lastly, more detailed and well-researched materials standards, governmentally enforced are, according to Dr. Einhorn, another necessity. The toxicity and amount of smoke generated by the addition of flame retardants and fireproofing treatments should be determined before such retardants are put into public use.—*S.J.N.*

More than One Hazard in Smoke

Where there's smoke there's fire, of course. But perhaps more important in terms of public health and safety is the realization that where there's fire there's smoke.

Smoke poisoning was the actual killer in 25 to 30 per cent of the fire fatalities in New York City in 1966-67. Of this 25 to 30 per cent, more than three-quarters were affected by carbon monoxide poisoning, and in 24 per cent of these cases the CO was lethal.

In a two-year study at the Columbia-Presbyterian Medical Center in New York, tests to determine the blood's carbon monoxide content were run on all the victims of fire admitted to the hospital. The results were presented by Dr. B. A. Zikria, who is affiliated with that hospital, at the annual American Chemical Society convention this summer.

Dr. Zikria found that victims of smoke poisoning developed respiratory problems which were often fatal even after treatment for carbon monoxide poisoning. So he suspected that carbon monoxide was not always the fatal ingredient. To test his theory he exposed dogs to standardized smokes of wood and kerosene. Surprisingly, the kerosene smoke neither killed nor injured the dogs, while the wood smoke caused severe lung damage. Half of the dogs exposed to wood smoke died of lung complications within 21 days—a close parallel to experiences with human patients.

Analysis of the two types of smoke showed only one significant difference between them: wood smoke contains 15 times the amount of aldehydes in kerosene smoke. Aldehydes are known to be extremely irritating to the mucus membranes and the lungs, and are believed to denature the amino acids and RNA in cells. Since large amounts of aldehydes are found in smokes of cotton, wool, and furniture, as well as wood, Dr. Zikria thinks they are the culprit in those deaths from smoke poisoning not explained by carbon monoxide.

The discovery may make a difference in how victims of smoke inhalation are treated in the future.

Dr. Zikria also found aldehydes in cigarette smoke, a discovery which may prove to be of significance, since the effects of aldehydes on the cells are cumulative for long or repeated exposures.—*S.J.N.*

Ferromagnetic Contamination

Every human has his own tiny magnetic field—no surprise if one considers that every electric current, including those in the human nervous system (to wit, encephalography), produces a magnetic force.

The normal human magnetism—the field resulting from the action of the heart, for example—is very small, perhaps 10^{-6} gauss. Studying this field last year for clues to heart disease, David Cohen of the Francis Bitter National Magnet Laboratory at M.I.T. discovered in some subjects an anomaly—a steady magnetic field of about the same size but apparently unrelated to internal current flow. By early this summer he was ready to report his findings in *Science* (*Vol. 180, pp. 745-48, May 18, 1973*): weak, steady-state fields produced by ferromagnetic particles in lungs or stomach, and perhaps in other organs as well.

He was observing what he calls ferromagnetic contamination (F.C.).

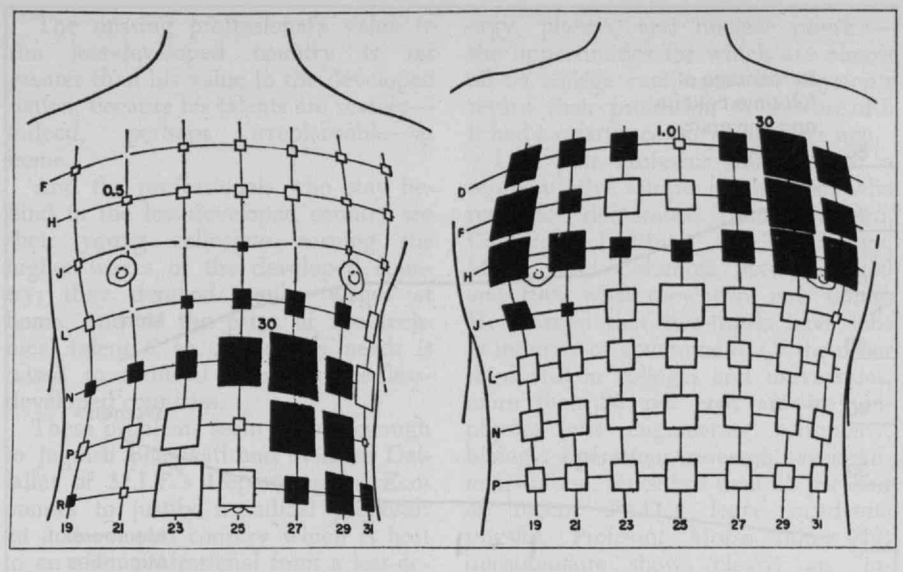
To study F.C., Dr. Cohen scans the torsos of his subjects twice in the Bittner Laboratory's shielded room—once after an "eraser" has been used to eliminate F.C. magnetism, and once after a steady field has been applied to magnetize the contaminating particles. The difference between the two scans gives an F.C. map which shows the amounts and locations of the contaminants.

Most subjects showed almost no F.C. in the lungs but a moderate amount in the abdomen. A welder turned out to have accumulated a "significant amount" of F.C. in his lungs, though his chest x-rays were normal. An asbestos worker had a similar burden of contamination, and Dr. Cohen thinks that—since the ratio of magnetite to asbestos is generally known for each asbestos mine—magnetic measurements may be a useful way to monitor accumulated asbestos in miners' lungs.—*J.M.*

SOLAR SYSTEM

Ganymede: A Moon Like a Planet?

Ganymede is Jupiter's third moon, some



These two maps show magnetic fields due to contaminants in subjects studied by David Cohen in the Francis Bitter National Magnet Laboratory. The map on the left was recorded 10 minutes after the subject had eaten several forkfulls of canned green beans; he had ingested microscopic particles of the can which were deposited in the food as it was opened. The map on the right shows the accumulation of ferromagnetic contaminants in a welder's lungs. Field strength calculations suggest that about 60 μg. of can particles were in the subject's stomach.

5,000 km. in diameter—larger than our moon, but hardly the size of a planet. Hence the interest in a report this fall that in at least one respect Ganymede may be more like a planet than a satellite in terms familiar to terrestrial man.

One June 7, 1972, the orbits of Jupiter and of Ganymede brought that satellite to eclipse the eighth-magnitude star SAO 186800 as seen in many parts of the southern hemisphere. Such an occultation is of special interest to astronomers because they then observe not only the two energy sources but the interaction of one on the other; so this crossing of SAO 186800 by Ganymede was watched by dozens of observers in South Africa, Australia, Java, and India.

The results:

—The occultation occurred within one minute of the predicted time, an acceptable result considering the difficulty of exactly establishing the orbits of bodies as small and dark as these.

—The occultation reduced the energy from SAO 186800 as seen on earth by roughly the amount predicted, an observation which tends to confirm previous estimates of the size of Ganymede. Analysis of reports from many observatories, reported in *Science (Vol. 182, pp. 53-55, October 5, 1973)* by an international team of astronomers, establishes Ganymede's diameter as 5,270 (+30, −~200) km.

—Measurements of energy flux during the occultation revealed that Ganymede's shadow was fuzzy, not sharp; indeed, write the astronomers, this is "the outstanding characteristic of the data." Their interpretation is that Ganymede must have "at least a modest atmosphere" through which SAO 186800's light was filtered as occultation began and ended.

All this suggests that Ganymede may be a satellite of more than usual interest; studies are continuing, and the astronomers suggest that Ganymede "receive first priority" in experiments planned for Jupiter-bound spacecraft.—*J.M.*

Lunar History in a Meteorite Era

When one large rock strikes another—as for instance, a large meteorite striking the moon—the shock produces small fractures called microcracks in nearby rock structures. Here on earth meteorite impact sites show microcracks spreading through many miles of rock.

But, despite the craters suggesting many such meteorite impacts on the moon, there are no microcracks in a layer of rocks between 25 and 60 km. below the lunar surface. This discovery, reported in *Science* (Vol. 182, pp. 158-161, October 12) by Professors Gene Simmons and Terry Todd of M.I.T. and Herbert Wang of the University of Wisconsin, holds what they believe to be "startling implications for lunar science."

Professor M. Nafi Toksoz of M.I.T. had earlier identified two discontinuities in lunar rocks at 25 and 60 km. Those discontinuities, depths at which sound waves travelling into the moon changed their velocities, are now explained since sound travels more slowly in rocks which have been affected by meteorite impacts. However, this explanation introduces a host of new questions.

Can it be that the lunar rocks which are now 25 to 60 km. below the surface in the mare regions—the areas for which the new data are valid—were solidified from a molten surface after the geological era of large meteorite impacts? Could the rocks now 25 km. below the surface have once been deeper—far enough down to escape the effects of meteorites? Have the rocks in those depths somehow been melted and reformed—thus eliminating the microcracks—since the time of the large meteorites? Microcracks are invisible to seismometers if filled with a liquid, such as water; is it possible that the moon is completely saturated with such a liquid 25 km. below the mare?

Of these and more possibilities, Professors Simmons, Todd, and Wang consider two to be most plausible: the rocks now found in the 25-to-60-km. depths on the moon existed only in the form of molten material at the time of large meteorite impacts; or the microcracks in these rocks have been annealed in a period of heating since the large meteorite bombardment. Choosing the first of these, the geologists offer this scenario of lunar development to account for their findings:

"During an initial stage 1, an outer shell hundreds of kilometers thick was liquid and the interior of the moon was solid. If impacts occurred, the resulting surface features would not have been preserved. During stage 2, the moon cooled, forming a crust that began at the surface and slowly increased in thickness. All major impacts (that is, those which produced shock effects at depths of 25 km. or more) must have ceased just when the crust reached a thickness of 25 km. During stage 3, the crust continued to thicken and the zone of melt thinned, but no large impacts occurred."—*J.M.*

Life: Bringing It Back Home

Even if it is science fiction, the problem posed in *The Andromeda Strain* is a real one—and to scientists, one with some conflict. How can we detect and study life from other planets and still remain safe from the dangers they may present?

One technique, to be implemented

by the unmanned Viking mission to Mars in 1976, is long-distance monitoring. Viking will scoop samples from the Martian surface, test the samples for growth and metabolic response, and relay the information back to Earth. Since this method, in effect, relies on growth by remote control and earth-side techniques, it has its drawbacks.

Bringing the samples back to Earth for study is another approach, but—aside from the matter of adequate space technology—this raises questions leading back to the classic science fiction horror story. How can we kill alien life forms without destroying evidence of their existence?

Dry heat sterilization has already been ruled out, according to L. E. Casida, Professor of Microbiology at Pennsylvania State University. It not only kills cells; it totally destroys them. Sterilization by autoclave also kills cells, but leaves many of the dead cells at least partially intact. Chemical sterilization using asmium or gluteraldehyde plus pasteurization is another alternative.

The experiments by Dr. Casida, using earth soil of course, are designed to make use of his innovative method of lifting organisms out of the soil for study under the electron microscope. Soils are subjected to a fractional centrifugation, or "washing", procedure, which separates even the most minute bacteria from the soil particles. To date, Dr. Casida believes that this method is the only one available to prepare soils for study by electron microscopy. Using this nondestructive technique, dwarf bacteria and bacterial cysts too small to be seen with conventional light microscopes have been isolated.

The eventual aim of this hurry-up study sponsored by the National Aeronautics and Space Administration is to find a successful way to sterilize extraterrestrial samples in transit, to kill and preserve the living material *before* it gets to earth.—*S.J.N.*

EDUCATION

Faculty Equality May Be Pipe Dream

Is equal representation for women and minorities on college and university faculties possible? It may be a pipe dream, at least until the year 2000 and perhaps beyond, warned the Carnegie Commission on Higher Education.

In compiling their pessimistic report, the Commission took into account these factors:

—Present proportions of women and members of minority groups on college faculties: in 1970, women and minorities on college faculties were 15.5 and 14.7 per cent behind their respective levels of representation as measured by the national labor force.

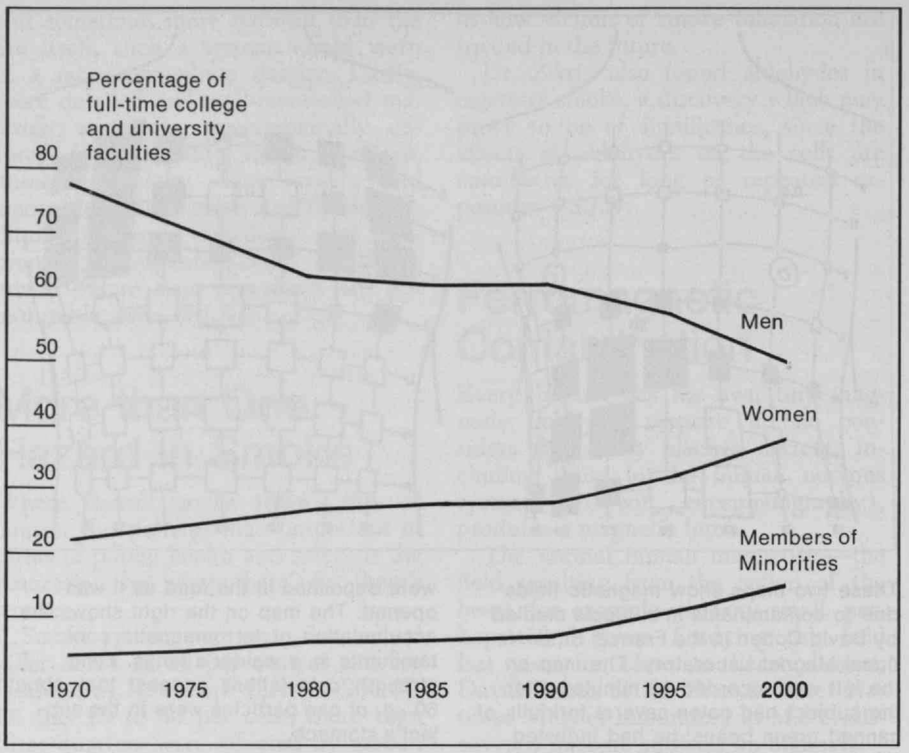
—Anticipated needs for new faculty members: Enrollments are expected to rise during the 1970s, creating some new positions. However, in the 1980s they will probably remain steady or decline, and while slow growth is expected in the 1990s, the rate of growth will not match that of the 1960s.

—Size of the graduate student pool of potential faculty members: in 1969 only 29 per cent of the graduate students were women, and 7.3 per cent were members of minority groups. This relatively small pool limits the potential increase of these groups in filling some of the new positions created in the 1970s.

—Age distribution of college and university professors: the 1980s will see little or no expansion of faculties, the faculties of that decade will include a high proportion of members hired in the boom of the 1960s. The comparatively few hires during this decade will be for replacement.

To reach the proportion suggested by the work force representation by 2000, the Commission suggests that hiring rates for women and minorities in the 1970s should be 35 and 10 per cent, respectively; for the 1980s 45 and 20 per cent, and 55 and 25 per cent in the 1990s. If this were achieved, women would comprise 39.2 per cent and minorities 15.6 per cent of full time faculty by 2000. However, these proportions would decrease the new hires of majority males from 58.5 per cent in the 1970s to 33.8 per cent in the 1990s, creating an imbalance in hiring practices and also placing a heavy burden on young majority males seeking faculty positions.

The Commission report concludes, "The way is clear to increase the proportions of those traditionally under-represented on faculties. But it will take a major effort in the graduate schools, and it will require constant reevaluation of hiring practices. It will also force many to confront rather uncomfortable realities. Above all, there is very little time to make the necessary adjustments. Without the effort today, 'ten years too late' could easily become 'thirty years too late'."—*S.J.N.*



The Carnegie Commission on Higher Education's projected differential hiring rates of women and minority members would increase their participation on college and university faculties to more representative proportions. It would also place majority males seeking faculty positions on a much more competitive level.

The True Cost of the Brain Drain

When a student from a less-developed country travels overseas for a technical or professional education and then fails to return to his native land with the skills he has acquired, his country loses more than the student's new country gains.

The missing professional's value to the less-developed country is far greater than his value to the developed nation, because his talents are scarcer—indeed, perhaps irreplaceable—at home.

And the professionals who stay behind in the less-developed country see their young colleague earning the higher wages of the developed country; they demand similar wages at home, and so the price of the technical talent it so desperately needs is raised to artificial levels in the less-developed countries.

These problems seem serious enough to Jagdish Bhagwati and William Dallalfar of M.I.T.'s Department of Economics to justify a radical proposal: let a developed country which is host to an alien professional from a less-developed country collect and remit to the visitor's homeland a special income tax. Two purposes would be served:

—The less-developed country would be compensated "for the real losses imposed by the brain drain."

—The brain drain itself would be partially deterred.

If the tax rate were set at 10 per cent and its duration the first 10 years of an immigrant's absence from his less-developed homeland, collections within the U.S. in 1969 would have been over $62 million—a significant fraction (over 10 per cent) of the foreign aid flow from the U.S. to less-developed nations in that year.

If a similar proposal were adopted by Canada, the U.K., and France, the flow from developed to less-developed countries might be $150 million. If "matching" grants were also made—a further possibility suggested by Messrs. Bhagwati and Dallalfar "on the broad supposition that the inflow of skilled manpower generally helps a developed country earn externalities at its research institutions and laboratories"—a $300 million annual fund can be visualized.—*J.M.*

Physics: The Price of Being Narrow

It's true that there seem to be more new physicists these days than there can be jobs for them to take—1,000 Ph.D.'s a year for the next half-decade, with only some 500 new openings on academic faculties.

But the other 500 need not wring their hands, thinks Philip M. Morse, Professor of Physics Emeritus at M.I.T., who founded the Institute's Operations Research Center and was largely responsible for creating the profession of operations research.

Instead of concentrating on such fashionable fields as theory, high-energy, plasma, and nuclear physics—the opportunities for which are almost all on college campuses—let physicists return their profession to the breadth it had a quarter-century and more ago.

Last year Professor Morse asked a representative sample of physicists who received doctorates from Harvard, California Institute of Technology, M.I.T., and Columbia between 1930 and 1960 what they were now doing. He learned that two-thirds have jobs in industry or government. Of the other third still in colleges and universities, more than 25 per cent are in non-physics jobs—engineering, astronomy, biology, operations research, even administration. Since less than 25 per cent of recent Ph.D.'s leave academic physics, Professor Morse thinks his questionnaire shows clearly an "increasingly ingrown tendency."

Hence his advice to his colleagues, writing in *Physics Today* late last spring: move out to reclaim for physicists some of the fields to which we once contributed but now neglect. Acoustics, the physics of the earth, systems analysis and operations research, even the study of ground water—which might include "adequate measurement techniques, masses of new data, and new theories of percolation, flow, and transpiration."—*J.M.*

The U.S. in Colleges

Federal funding to all U.S. colleges and universities in 1971-72 was a record $4.1 billion; figured in 1967 dollars, this was almost exactly the same as the 1966-67 total of $3.3 billion.

Of this total, academic science funding was $2.6 billion; and of this, $1.85 billion was for research and development. The figures (as given in current dollars) were, respectively, 18, 11, and 19 per cent larger than in 1970-71. In 1963-64 science took 94 per cent of all federal funding for colleges; nine years later it claimed but 63 per cent.

The largest single source of funds was the Department of Health, Education and Welfare, and workers in the life sciences ($1.12 billion) were by far the largest beneficiaries. Other fields showing sizable increases in federal funding were the environmental sciences ($187 million) and engineering ($193 million). But some forms of federal support for science declined: training grants and fellowships, general support, and facilities and equipment.

In addition to H.E.W., the National Science Foundation ($459 million) and Department of Agriculture ($239 million) increased their commitments to colleges and universities in 1971-72. The Department of Defense, N.A.S.A., and Atomic Energy Commission showed a combined decrease of 6 per cent.

The largest single recipient of federal funds for higher education in 1971-72 was M.I.T. (including both Draper and Lincoln Laboratories). The total was $112 million—far ahead of next-running University of Washington ($73.3 million) and University of Michigan ($66.8 million), according to the National Science Foundation analysis from which all these figures come.—*J.M.*

FOOD

Tomato Engineering in the Desert

Can engineered tomatoes from arid regions compete in the commercial marketplace?

Indeed, tomatoes grown in a controlled (engineered, if you will) environment in Arizona absorb the cost of air shipment to New York and still bring a satisfactory return to their producer, Environmental Farms, Inc.

How about other crops—can they be grown under-cover and marketed profitably? They can certainly be grown, says Carl N. Hodges, Director of the University of Arizona's Environmental Research Laboratory, which developed the controlled environment system in cooperation with Mexico's University of Sonora under a Rockefeller Foundation grant. But successful marketing, or utilization, is presently restricted to high-value crops and depends on local conditions in arid regions of the world.

The key to commercial success in this sort of venture, Dr. Hodges told the Congress of Science and Man in the Americas in Mexico City last summer, is high productivity. Environmental Farms grows 2½ crops of tomatoes per year yielding 150 tons/acre. In the same period a conventional tomato farmer will harvest 30 tons/acre from a single crop.

But tomatoes don't grow well in very hot places. So why pick the nation's furnace as the site for Environmental Farms' pilot commercial plant? Because, says Dr. Hodges, the plant's high productivity depends upon the great amount of direct sunlight in Arizona. The major engineering problem, therefore, was keeping the inside temperature of the 10-acre covered farm at a healthy level while the outside temperature was as high as 120°F.

The cooling requires two airstreams—one of them bubbled through 100 gal./min. of brackish well-water in an asbestos pack and then circulated around the tomato plants, and the other stream continuously flowing through a double-layer polyethylene roof. The

About 3 million lbs. of tomatoes are produced at Environmental Farms, Inc.'s 10-acre covered farm in Arizona (top). The annual per-acre yield in this controlled environment is about 5 times greater than that of conventional tomato farms. Air-freighted, these vine-ripened tomatoes compete well against truck and rail shipments of green tomatoes from open fields. The technique was developed largely at the University of Arizona's Environmental Research Laboratory (bottom).

temperature is held to 75° to 85°F. during the day and 60° to 65°F. at nighttime.

Plants in deserts normally transpire 1000 times their own weight in water from seed to maturity—an untenable cost in regions of high-priced water. Moistening the environment converts the same plants into efficient users of water.

The tomato plants are grown in sand, and they are fed closely controlled amounts of nutrients by a trickle system. Irrigation and humidifying water and power are supplied by the City of Tucson. Under these conditions, a high-quality, profitable tomato is produced.

Quite different conditions exist in another Environmental Research Laboratory plant in Abu Dhabi on the Persian Gulf. This enclosed farm was developed under a grant from the tiny, oil-rich shaikhdom for establishment of an Arid Lands Research Center. Located on the island of Sadiyat 2.4 km off the Arabian Peninsula, the farm consists of five acres of greenhouses, a three-diesel power plant, and a 265,000-liter/day desalting plant for irrigation water.

The plant's water is drawn directly from the 85°F. gulf. At that temperature it is eminently suitable for desalting, but not for cooling the greenhouses by sensible heat transfer. To provide evaporative cooling and humidity, air is blown through a stream of seawater.

The Abu Dhabi system produces about 1000 kg/day of vegetables—cucumbers, tomatoes, lettuce, beans, radishes, eggplant, spinach, cauliflower, and cabbage. The island's 30 families market the surplus on the mainland.

Though not profitable in the corporate sense—its power and desalting expenses impose a financial burden that possibly only an economy sitting on a large recoverable pool of underground oil can bear—Dr. Hodges says the controlled environment farm is operating successfully under conditions peculiar to Abu Dhabi.—*R.S.*

Fats: To Saturate or Not to Saturate

Is one egg enough? Are three too many? Is there direct evidence of a relationship between a high cholesterol, saturated fat diet and coronary heart disease, cholesteremia, and shortened life expectancy?

The publicity given to recent and as-yet-incomplete medical evidence on the subject and advertising campaigns capitalizing on that uncertain situation have led to a high level of national toxicophobia about what or what not to eat. For those who have subscribed to the unsaturated-fat pledge, a word of caution is offered.

Surprising results have come out of a 15-year study of the effects of cholesterol and saturated fats on rats. This new information contradicts previous studies which contributed, as stated in the famous Framingham study (*Technology Review, December, 1970, p. 61*), to the "impressive array of evidence [linking] total blood cholesterol with the development of atherioscleросis and coronary heart disease."

In this most recent work, by Dr. Teh C. Huang at Timken Mercy Hospital, Canton, Ohio, rats were fed diets of different combinations of cholesterol, saturated fats, unsaturated fats, and antibiotics. The test group on the diet that included cholesterol and saturated fat, with the addition of antibiotics, had the best growth and health record. Second best were those on the same diet without antibiotics. Those fed cholesterol and unsaturated fat, with or without antibiotics, had the poorest growth record.

The result is to throw doubt upon the current movement to condemn saturated fats.

A second experiment showed that cholesterol prolonged the lives of rats fed either saturated or unsaturated fat. While the males did better on saturated fat and the females on unsaturated fat, either diet was harmful without the addition of cholesterol. In his report to the American Chemical Society last summer, Dr. Huang said cholesterol must be provided by the diet or the body must overwork itself to produce it. "The [American] Heart Association should restructure its stand on cholesterol," he said.

But before you start supplementing your diet with cholesterol and saturated fat, a word of caution: Dr. Huang also

did a short experiment to test the digestibility of the two fats. Unsaturated fat was shown to be more digestible, aiding in the absorption of cholesterol. Since the body provides itself with cholesterol through synthesis and absorption, this is an important function. Also, although Dr. Huang's statement warns against the harmful effects of too little cholesterol in the diet, he makes no statement on the effects of an oversupply.

Dr. Huang does not overrate his findings. Rats, after all, are not human, although they have a closer nutritional resemblance than the rabbits that have been used in many previous experiments.—*S.J.N.*

Meat: The Growing Problem of Leftovers

Never mind the old saying: meat packers do not manage to use all the animal except the squeal. Never did. And therein—in the new age of environmental concern—lies a problem.

The Federal Water Pollution Control Act now requires meat packers to reduce waste discharges and improve waste treatment, and what used to be thrown away now must come under sharp scrutiny. Blood, for example: An average steer contains at least 22 quarts of blood. Conventional slaughterhouse procedures let perhaps 30 per cent of this flow as waste into sewers. Now meat packers are learning to be more careful, and only about 10 per cent of the blood is flushed away. The rest—along with other oddments—goes into animal feed, tallow, and fertilizer.

At the time of slaughter, an average steer's stomach and intestine contain up to 60 lbs. of partially digested food. This used to be washed away with water, the solids later filtered out and the water sent on to the sewer. Now it is handled dry—and some of it recovered for use in by-products.

A recent study at Armour Food Co. plants showed that half of its slaughterhouse wastes went into the sewers during clean-up, not during operations. Using "dry" instead of "wet" clean-up has reduced the load to the sewers by 50 per cent.

What about the smoke let out of the smokehouse after the hams are finished? Such excess smoke now comes out as air pollution. The answer is to use atomized or liquid "smoke"—solutions and suspensions of the products of hardwood combustion sprayed or atomized onto hams and sausages, which are then cooked without smoke.

Changes such as these are only the beginning, said Evan F. Binkerd, Armour's Director of Research, speaking at a food processing symposium at M.I.T. this fall. By 1983 near-complete removal of suspended solids, fat, oil, grease, and nutrients such as phosphorus and nitrogen will be required in waste water from meat packing, and similarly stringent regulations will affect air pollution (including odors) and solid wastes.

Can these ambitious goals be realized? Mostly yes, said Mr. Binkerd, in the sense that cost, not technology, is the limiting factor. But when it comes to controlling nitrogen and phosphorus in waste water, new technology at uncertain cost will be needed.

The National Industrial Pollution Control Council thinks all this may cost the meat and rendering industries as much as $385 million by 1976 (the government estimate is $53 million); Mr. Binkerd simply spoke of "sharply increased costs."—*J.M.*

Water and Food

Behind the dark cloud of pollution control (*see above*) is a silver lining. In its efforts to reduce water pollution at one meat packing plant (in Memphis, Tenn.), Armour Food Co. has cut water consumption there from 29 to 14.5 million gal./month.

That news from Evan F. Binkerd, Armour's Director of Research, was welcome to Walter A. Mercer, Director of the Western Research Laboratory of the National Canners Association, who was honored as Underwood-Prescott Lecturer at the M.I.T. food processing symposium this fall.

"The story of man's civilization can be written in terms of his concern about water," said Mr. Mercer—indeed, he said, there are no less than 650 references to water in the Bible. Today's Americans are "the most water-extravagant" people in world history—1,600 gal./day per person, an average of 550 gal./day for a family of four simply for household needs, perhaps 2,000 gal./day per person by 1975.

As a food expert, Mr. Mercer was especially eloquent about agricultural uses of water: 500 lbs. of water needed to grow one pound of wheat; one ton of water to grow and process one pound of granulated, white sugar; 60 to 70 lbs. of water needed every day by a beef steer, 85 to 180 lbs. by a dairy cow; at least 2,000 lbs. of water for the food in every American family's meal; 150 gal. of water to process every 100 lbs. of raw food; 90 billion gallons used every year in canning and freezing food.

But in that last figure lies the wave of the future, said Mr. Mercer. Food canning and freezing actually require some 330 billion gal./yr., but the industry has found ways to reuse nearly 75 per cent of this. Prodded by water conservation and pollution control, Mr. Mercer thinks the food industries will do even better in the future.—*J.M.*

Protein from Plants

Lots of Americans worried about the high cost of meat are turning to vegetable proteins—soybeans, wheat glutin, and oil seeds.

They're right: a 75/25 mixture of soybean and corn flour (total 50 per cent protein) contains nearly all of the essential amino acids in at least the quantities represented in red meat, at 14 cents/lb. A concentrated flour (70 per cent protein) costs 30 cents/lb. and vegetable protein isolates (90 per cent protein) cost 45 cents/lb.

Vegetable protein has even more than money going for it. Plants are more efficient protein producers than animals. An average acre yield of 2100 lbs. of soybeans produces 840 lbs. of protein. An acre devoted to beef production, on the other hand, yields an average of 1500 lbs. of beef and 135 lbs. of protein. From dairy production, the annual yield per acre is 9,900 lbs. or 154 lbs. of protein.

Another point: beef cattle produce as much as 20 times the organic waste per pound of protein as soybeans.

Processing soybeans into flour involves a five-stage process—cracking, dehulling, flaking, roasting, and fine grinding. Everything is done without water—in marked contrast to meat processing (*see above*). No water pollution control problems.

The situation is not so simple when it comes to the concentrate and the isolate, which are made by extraction processes in which nonprotein constituents are dissolved away. The solvent waste material from the isolate is "a mess," admits Robert J. Dimler, Director of the Department of Agriculture's Northern Regional Research Laboratory at Peoria, Ill., with a content of some 12 per cent protein, 45 per cent sugars, and miscellaneous minerals and "this and that." What to do with it remains an unresolved problem which may soon add up to 10 per cent to the price of the isolate. Some possibilities: separate out the protein (by concentrating and drying the waste or by membrane separation) and reuse the half of it that is of suitable quality; the remaining may be fermentable. Or separate out the protein by drying, grinding, and air classification—the protein being more particulate in structure than the associated sugars.

Lots of work still to be done, said Dr. Dimler—the only word of comfort from the vegetable protein man for the meat-industry representative (*see above*) at the Underwood-Prescott symposium at M.I.T. this fall.—*J.M.*

Touch Football and Tired Camels

Puzzle Corner
by
Allan J. Gottlieb

Here at Rockefeller University some of us play a little touch football on weekends. During the last few weeks, the New York Jets have had their top two quarterbacks injured. As that happens to be my position, I am beginning to have dreams of glory; but unfortunately their practices conflict with the computer course I teach.

As you may remember, the first problem in March/April, 1973, was printed incorrectly and revised in June. So this month we will print solutions to six problems—the revised **M/A1** and the five problems given in June.

Often I receive many correct responses to a given problem, and I've been asked how I decide which solution to print. If an answer is hard to read it is rejected. A typed solution gains a few brownie points, as does one which does not abound in many hard-to-type and hard-to-print special symbols. After that it comes down to my mood and the luck of the draw. I try to give preference to those whose names are new to Puzzle Corner; no extra priority is given to letters received early in the month.

Problems

Here is a novel bridge problem from Charles E. Blair:

DEC1 Construct a hand on which North-South can make seven of any suit but cannot make seven no trump. You are allowed to make up the East and West hands but you must allow for best play by the defenders.

Here is a geometry problem from Norman I. Apollonio:

DEC2 A hexahedron (I call such things cubes—ed.) has three regular sections: an equilateral triangle, a square, a regular hexagon. Prove that it cannot have a fourth—namely, a regular pentagon.

A political problem from Frank Rubin's doctoral dissertation:

DEC3 A body of N legislators is divided up into various (possibly overlapping) committees. An executive committee is formed consisting of at most one representative of each committee (the same individual will represent every committee of which he is a member). The executive committee is always chosen to be as large as possible without violating the rule that only one member from any other committee may be on the executive committee. How large is the executive committee?

On another topic, here's a question from Hal Varian about the possibility of stable marriages:

DEC4 Each of n men has a preference ordering of n women; each of the n women has a preference ordering of the n men. A marriage is an assignment of the n men to the n women. A marriage is called unstable if some man prefers another woman to his present mate and the preferred women also prefers this man to her present mate. Can you always find stable marriages?

Jeff Dodson writes:

DEC5 I can generate an infinite number of "magic squares" using

0 2 1
2 1 0
1 0 2

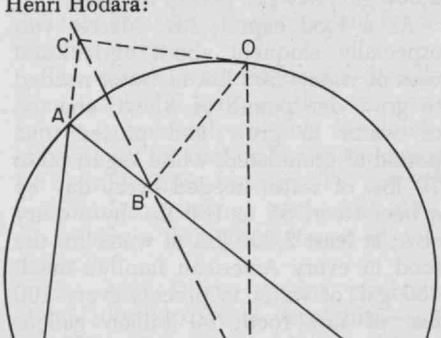
as well as its three rotations, and linear multiples. These all have rows, columns, and diagonals which add up to a multiple of three. Can you find a three-by-three array of integers all of whose rows, columns, and diagonals add up to the same number without this number being a multiple of three?

Speed Department

This is from H. W. Hardy:

SD1 The sum of Mary's and Ann's ages is 44. Mary is twice as old as Ann was when Mary was half as old as Ann will be when Ann is three times as old as Mary was when Mary was three times as old as Ann was. How old is Ann?

Our last problem this month is from Henri Hodara:

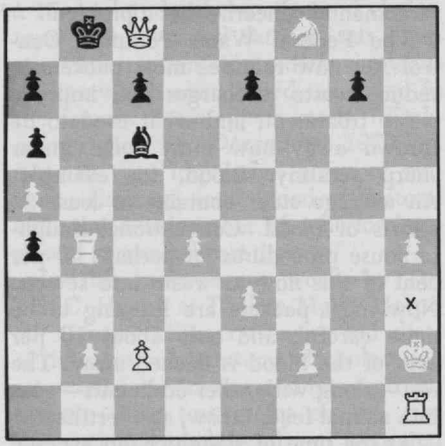


SD2 Inscribe a scalene triangle ABC in a circle. Pick any point O on its circumference. Draw from O the perpendicular to the three sides of the triangle and call the intersections, A', B', and C'. Show that these three points lie on a straight line.

Solutions

The following correctly states the first problem published in March/April, 1973:

M/A1 Given a chess game interrupted at the point shown by the board below, what piece must have been at X?



The answer was supposed to be a black knight. Unfortunately, Avi Ornstein can show that the piece cannot be white and cannot be black:

1. To be in the present condition, the, move before the interruption had to be White's KNP taking a piece at QB8, becoming a queen, and achieving a double check.
2. In moving Black's QNP to QR3, a white piece was taken.
3. In moving Black's QP to QB3 to QN4 to QR5, three white pieces were taken.
4. All of these captures were on white squares, so White's QB was captured elsewhere.
5. This accounts for all of White's pieces which are missing, so the piece knocked off of White's KR3 was not white.
6. White's KNP captured six black pieces by moving to KB3 to K4 to Q5 to QB6 to QN7 to QB8, where it became a queen.
7. Black's KB was captured elsewhere. This can be shown by two points: it could not have been on any of the white squares traversed by White's KNP; and it never left its original position, since both Black's KP and KNP have not moved.
8. Black's KRP was also taken elsewhere (he could not have moved to White's KR3 without having captured two addi-

tional white pieces).

9. This accounts for all of Black's pieces which are missing, so the piece knocked off White's KR3 is not black.

10. With 5. and 9. we therefore are back at the original difficulty. There were two errors, not one, in the puzzle as it originally appeared.

Thirty-one other readers have also responded—a list which is simply too long for publication here. Sorry—it doesn't often happen, but paper is scarce this year.

The following solutions are to problems published in the June, 1973, issue:

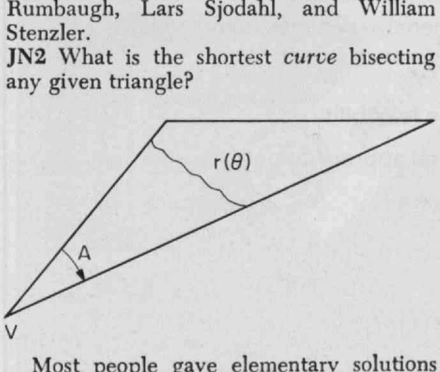
JN1 What is the minimum number of legal moves necessary to reach the following position (either side may move first, and in either direction)?

The following solution, showing 20 moves, is from Bruce Parker:

1	N-QR3	N-QR3	11	N-K5	K-K1
2	N-B4	N-N5	12	NxN	K-Q1
3	N-N6	N-Q4	13	NxR	K-K1
4	NxB	N-N3	14	N-N6	K-Q1
5	NxN	N-KR3	15	NxB	K-K1
6	NxR	N-N5	16	N-K6	K-Q1
7	N-N6	Q-B1	17	N-B4	K-K1
8	NxQ	N-K4	18	N-Q5	K-Q1
9	N-Q6	N-N3	19	N-QB3	K-K1
10	N-B4	K-Q1	20	N-N1	

Also solved by Edward Gurshuny, James Rumbaugh, Lars Sjodahl, and William Stenzler.

JN2 What is the shortest *curve* bisecting any given triangle?



Most people gave elementary solutions which assumed that the necessary curve was a circle having its center at a vertex. While this is in fact correct and seems "intuitively obvious," it should I believe be proved. The following solution from James Rumbaugh assumes only that the curve is differentiable. Unfortunately, it is very advanced—another case of mathematicians using high-powered machinery to prove "obvious" results:

Assertion: The shortest curve bisecting a triangle is a circle centered at the vertex V with the smallest angle. The radius of this circle is $(K/A)^{1/2}$ and the length of the relevant arc is $(KA)^{1/2}$ where K is the area of the triangle and A is the measure of the smallest angle (in radians, of course). Proof by calculus of variations (I warned you—ed.). Use polar coordinates about V and let A be the measure of the angle (it will be clear later that the correct vertex is the one with the smallest angle). We want to minimize

$$ds = \int_0^A (r^2 + r'^2)^{1/2}\, d\theta$$

with the constraint that

$$\int_0^A (r^2\, d\theta)/2 = K/2.$$

Let t be positive and try to minimize

$$\int H\, d\theta$$

where $H = (r^2 + r'^2)^{1/2} + t\, r^2/2$.

We have the solution to the Euler equation:

$$H - r'(\partial H/\partial r') = C$$

and boundary conditions

$$\partial H/\partial r'|_0 = \partial H/\partial r'|_A = 0.$$

Plugging in gives

$$r^2 + (1-t)r'^2 - C(r^2 + r'^2)^{1/2} = 0$$

and $r'(0) = 0$ and $r'(A) = 0$. So let r be the constant C (hence $r' = 0$), and we get a solution. Since we require $r^2A/2 = K/2$, we get that $rl = (K/A)^{1/2}$ and thus the length $= rA = (KA)^{1/2}$. As K is constant we should choose A to be the smallest angle.

Also solved by Winslow Hartford, R. Robinson Rowe, and Harry Zaremba.

JN3 If you take a two-digit number, A_1A_2, and subtract the number obtained when you reverse the digits, A_2A_1, you obtain a positive multiple of 5. Divide this number by 5 and you obtain one of the factors of both the original number and the reversed number. Find the original number.

The following solution is from Joseph Evans IV:

The two-digit number A_1A_2 may be represented as $10A_1 + A_2$. Similarly, A_2A_1 may be represented as $10A_2 + A_1$. The problem statement then becomes: $10A_1 + A_2 - 10A_2 - A_1$ is evenly divisible by 5, is positive, and is 5 times a factor of both the original and the reversed number; find A_1 and A_2. Or: $9(A_1 - A_2) > 0$ ("positive multiple"). And, since the difference of digits between 0 and 9 cannot exceed 9 nor be < 0, and 5 is the only multiple of 5 in that range, $A_1 - A_2 = 5$ ("multiple of 5"). Also, $[9(A_1 - A_2)]/5 = 9$ (9 is the common factor). The multiple of 9 the difference of whose digits is 5 is 72, and since $A_1 > A_2$, $A_1A_2 = 72$ and $A_2A_1 = 27$.

Also solved by Arthur Anderson, Bob Baird, Sam Bent, Joseph Evans IV, Mrs. Leonard Fenocketti, Edward Gershuny, David Glazer, Jean Goodwin, Winslow Hartford, John L. Joseph, Paul Karvellas, Mrs. Martin S. Lindenberg, Roger Milkman, Avi Ornstein, Bruce Parker, John Prussing, R. Robinson Rowe, James Rumbaugh, Joel Shwimer, Lars Sjodahl, William Stenzler, Paul G. N. de Vegvar, Neal Wellmer, D. Zalkin, and Harry Zaremba.

JN4 Two football teams of equal strength compete each year for a cup. The first team to win the game three years in a row keeps the cup. Assume each year's game is independent of the previous year's and each team has probability $p = 1/2$ of winning. What is the probability that a given team wins the cup at the nth trial?

An outstanding variety of methods was employed for this problem. After giving his solution, James Rumbaugh stated that a longer method was to use difference equations. This was prophetic, as H. M. Wilensky used these equations and some theory of Markov chains to get an unbelievably hairy method. I present a digested solution based primarily on those of Rumbaugh, Harry Zaremba, and Winslow Hartford: The number of possible n-strings of victories and losses for team is clearly 2^n. By inspection, there are exactly 1, 1, and 2 n-strings ending in a victory for A when n is 3, 4, and 5, respectively. They are WWW, LWWW, LLWWW, and WLWWW. Consider the Fibonacci sequence 1, 1, 2, 3, 5, 8, 11, etc., satisfying $F_{n+2} = F_{n+1} + F_n$. I claim that the number of n-strings ending in a victory for A (call this number S_n) is just F_{n-2}. By inspection this checks out for $n = 3$, $n = 4$, and $n = 5$. So all I must show is the recursion relation $S_{n+2} = S_{n+1} + S_n$. The answer will then be $(F_{n-2})/2^n$. Using standard results on the Fibonacci sequence we can see that the probability approaches $1/2$ as expected. Proof of re-

cursion relation ($n > 3$): call an n-string legal if it contains neither LLL or WWW:

Let a_n = number of legal n-strings ending in LWW,
b_n = number of legal n-strings ending in LW,
c_n = number of legal n-strings ending in WL, and
d_n = number of legal n-strings ending in WLL.

Following Rumbaugh we note that $a_n = d_n$, $b_n = c_n$, $a_{n+1} = b_n$, and $b_{n+1} = d_n + c_n = a_n + b_n$. Thus $b_{n+2} = b_{n+1} + b_n$. Since $b_2 = 1$ and $b_3 = 2$, $b_n = F_n$. Each n-string in S_n is just an element of b_{n-2} with WW stuck on the end. So $S_n = b_{n-2} = F_{n-2}$ as desired.

Also solved by Arthur Anderson, Bob Baird, Edward Gershuny, Jack Parsons, R. Robinson Rowe, and Lars Sjodahl.

JN5 A camel must carry 3,000 bananas from A to B, which are separated by 1,000 miles. The camel can carry no more than 1,000 bananas on its back, and it eats one banana a mile. How can it arrive at B with the most possible bananas?

For the camel's health I have selected the solution from Ray A. Brinker, M.D.:
1. At first it takes five bananas eaten per mile gained because five one-way trips are required.
2. Where is the first stopping point? This is probably where only three one-way trips are subsequently required; therefore, 200 miles out. After five trips, there are 2,000 bananas and one tired camel at point 200 miles.
3. For the second trip it is likely that the best distance is where 1,000 bananas are left (and so only one trip to point B). This is 333 miles from the last stop and 533 miles from the start. At this point we have 1,001 bananas and one *very* tired camel.
4. There are now 467 miles left to go—using 467 bananas for camel food leaves 533 bananas to sell at point B (plus one banana wasted in the desert).

Dr. Brinker explains that "the above solution is rambling because, among other reasons, I am an applied biologist, not a scientist."

Also solved by Arthur Anderson, Bob Baird, Bruce Cuthbertson, Edward Gershuny, Otto Hadler, Karl Kadzielski, Erich Kranz, Mrs. Martin Lindenberg, Roger Milkman, Avi Ornstein, Bruce Parker, R. Robinson Rowe, James Rumbaugh, Joel Shwimer, Lars Sjodahl, Benjamin Whang, Norman Wickstrand, and Harry Zaremba.

Better Late Than Never

In connection with **SD1** in June, James Rumbaugh, Sam Bent, Roy Schweiker, and Benjamin Whang have pointed out that a half inning of baseball can occur with *no* pitches thrown. For example, batters can be declared out for not respecting rules concerning the batter's box; the umpire can call a "ball" if he decides the pitcher is delaying the game; and pitchers wetting their fingers while on the rubber cause the batter to take first. Surely now we are at the theoretical minimum.

JA4 John E. Prussing has furnished solutions for all bases from 3 to 10. His answers are as follows:

Base	Solution	Decimal equivalent
3	1,012	32
4	102	18
5	102,342	3,472
6	1,031,345,242	10,993,850
7	103,524,563,142	2,129,428,800
8	1,042,	546
9	10,467,842	5,064,320
10	105,263,157,894,736,842	same

DEC4 (1972) Lars Sjodahl agrees with the proposer that the published solution is in error. He pinpoints the mistake to be the assumption that all solutions of the algebraic equation are solutions to the problem.

FEB3 Harold Chelemer points out that if we work base-14 there is a unique solution, namely

$$\begin{array}{r} 7\ 3\ 4\ 3 \\ 1\ 5\ 3\ 8\ 3\ 7\overline{)9\ Y\ 4\ 9\ 9\ 5\ 3\ V\ 7} \end{array}$$

where we have denoted the fourteen digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, V, X, and Y.

Solutions have been received from the following as indicated:
B. Rouben—**MAY2** and **MAY3**
Paul G. N. deVegvar—**MAY4**

Allan J. Gottlieb, who studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973), teaches at York College of the City University of New York. Send problems and solutions to him at the Mathematics Department, York College, 150-14 Jamaica Avenue, Jamaica, N.Y. 11432.

The High-Percentage Line

Bridge
by
Earl Woltz

My editor has just instilled in me the necessity of meeting a deadline. I'm still not certain what he was talking about, as card players aren't expected to make deadlines! However, one card player who met his deadline by graduating on time is Bart Bramley ('69, Math.). Bart has consistently done well in major tournaments. Edging closer to a national title, Bart has made it to the quarter-finals in the last two major team championships before losing to Kaplan's team in the Vanderbilt, and Reinhold's team, by a scant IMP, in the Spingold. In the Vanderbilt, Bart's team defeated teams headed by Becker and Goldberg, while in the Spingold, they beat the Dallas Aces. The Aces and Becker's team were two of the five teams participating in the recent World Championships.

Bart's forte is his competitiveness and his consistent, logical play. He invariably finds the high-percentage line, as is evidenced by his play of the following hand.

Both Vulnerable: IMP's

(M. Granovetter)
♠ A
♥ A10xxx
♦ J109
♣ AK8x

(Bramley)
♠ Qxx
♥ KJxx
♦ Ax
♣ Q1096

Bidding:

S	W	N	E
1C	P	1H	P
2H	P	4C	P
4D	P	4S	P
5H	P	6C	P
P	P		

Opening lead: small spade.

On this deal, Bart won 16 IMP's for his team in a Florida regional, when he took a slightly higher percentage line than his opponent did. The bidding is fairly standard (for an expert) with the 4D, 4S, and 5H bids being cue bids. The opening spade lead enabled Bart to demonstrate his superior declarer skills. What was Bart's line and why is it better than the more obvious play? In fact, what is the more obvious play? The East-West hands have been omitted since their presence would rapidly direct the reader to the proper play.

Please send any answers and/or comments to me, care of the *Review*. For those who are interested, Bart is presently a computer programmer and lives in Waltham, Mass.

The author is a doctoral student in the Department of Chemical Engineering at M.I.T. His card-playing career began among the experts in M.I.T.'s Baker House. A solution to October/November's problem will appear in the January issue.

Books

S.A.L.T. on Sunday: Some Comic Relief

Cold Dawn: The Story of S.A.L.T.
John Newhouse
New York: Holt, Rinehart and Winston, 1973, viii—302 pp., $7.95

Reviewed by Kosta Tsipis

I know it's the end of the football season, so if I ask for your indulgence and distract your attention from a fourth-down-and-goal-to-go-situation, it is because I have come across some alarming evidence that Roi Ubu and the rest of the heroes and satraps from the theater of the absurd have taken our government over.

You see here is this guy, John Newhouse. He has written a book he calls *Cold Dawn* in which he describes the S.A.L.T. talks on arms limitation between the U.S. and the Soviet Union. Now this book is chock-full of the most fascinating details about the top-secret negotiations that culminated in the signing of the S.A.L.T. agreements in Moscow on May 26, 1972. Yet as far as I know Mr. Newhouse has not been dragged to court accused of aiding and abetting the enemy by revealing national security secrets, à la Daniel Ellsberg. Since the S.A.L.T. negotiations are continuing, it is certainly helpful for the Russians to know what transpired on the U.S. side during the first S.A.L.T. talks.

It is clear that one had to be a member of the National Security Council or a staffer for Mr. Kissinger to be privy to all this wealth of authoritative information spread throughout the 300-odd pages of the book. Mr. Newhouse is not; yet he has not been subpoenaed to name his interlocutors during the "innumerable private conversations" that he acknowledges in the Introduction as the sources of his prodigious (and precocious) knowledge of detail. No non-union plumber has come forth to admit stealing Mr. Newhouse's medical records; neither is he identified in any of the White House gothic memoranda as a prospective subject for "bleeding for a while" or "turning slowly in the wind." To cap it all, Mr. Newhouse is not even a colonel in the Russian Army; and that makes me very suspicious, because if he were, then I could understand where he got all this information about our nuclear weapons and strategic postures.

You see, one of the provisions of the S.A.L.T. agreements (which, by the way, I consider to be the most significant result of the negotiations and Mr. Newhouse somehow has overlooked) is that not only will we allow the Russian military to find out all they want about our strategic weapons (provided they do it from at least 50 miles up), but also that we promise not ever to interfere with them. So the Russian colonels are authorized to know what we in this country casually label "sensitive national security secrets" and carefully keep hidden from the eyes of all our pesty fellow citizens. After all you can't trust those civilians; they might start asking embarrassing questions if they could find out how the Pentagon spends $80 billion of their taxes per year.

But we should not complain. For true excellence in keeping secrets from the citizenry we will have to turn to the Russians' example. It says here on page 192 of the book that Mr. Semenov, the head of the Soviet delegation that was sent to Vienna to negotiate with the Americans on mutual limitations of strategic weapons, did not know the difference between a Minuteman III and a SS-9; furthermore, when the Americans clued him in, the Russian military expert Col.-Gen. Ogarkov took Paul Nitze aside and complained bitterly that we are revealing Russian military secrets to a Russian civilian, who incidentally happened to be the head of the Russian S.A.L.T. delegation! Now you must admit that not even John Ehrlichman defending the supreme dominance of the national security imperative would have that kind of *chutzpa*.

Now don't tell me that I am unduly and easily alarmed by such small absurdities, because there is much more: about the "Treaty Between the United States of America and the Union of the Soviet Socialist Republic on the Limitation of Antiballistic Missile Systems," here on page 273 it says in effect that we cannot build any A.B.M. sites beyond the one completed in Grand Forks Air Force Base and one we could build around Washington D.C.; yet we have spent over $1 billion on A.B.M.s since the treaty was signed a year ago May.

The entire S.A.L.T. agreements were heralded as a positive step towards limiting the arms race and the proliferation of new strategic weapons systems; yet only last month, with the unstinting help of the White House and the munificent blessings of the Congress, the Navy launched upon a program of constructing a new force of ballistic missile submarines each of which is estimated to cost *before overruns* (and you know what *that* means) $1.3 billion. The Navy says we need a dozen of these if we are not to be overrun by the red monolith of Communism. Many years ago the U.S. developed a new way of delivering nuclear warheads to their targets known as M.I.R.V. with the explicit purpose of overcoming a Russian A.B.M. system. Since the S.A.L.T. agreements that in effect ban A.B.M.s, leaving Russia with no such operational system, we have installed M.I.R.V.s on several hundred Minuteman I.C.B.M.s and an additional half-dozen Polaris submarines.

Is S.A.L.T. a Paregoric?

Well, you've missed that fourth-down situation anyway, so you might as well take a break and think about all this. Are all these inconsistencies in our policies towards secrecy or in our procurement and deployment of superfluous, yet deadly, strategic weapons accidental? Does S.A.L.T. really represent a genuine desire to curb the proliferation of frightfully expensive weapons, or is it a mere paregoric to quiet those concerned with the exorbitant military expenditures so that business at the Pentagon can continue as usual? Mr. Newhouse doesn't seem to care for such a critical look at S.A.L.T. He thinks the agreements are great progress towards disarmament, and that's the price he may have had to pay for all those delicious morsels of bureaucratic gossip that his thoroughly entertaining book contains.

However, as one looks more closely at the development of the nuclear confrontation between the United States and the Soviet Union during the last quarter century, one begins to recognize that perhaps the arms race is a myth. All these inconsistencies between declared strategic policies and weapons procurement point to a nonsymmetrical and noncompetitive process in which consecutive United States Administrations appear to have repeatedly initiated new weapons systems and then invented strategic postures to justify their deployment, almost independently from the actions of the Soviet Union—actions that in historical perspective appear more emulative than competitive.

If this is in fact the case, then international negotiations such as S.A.L.T. are not the most efficient way to control weapons' proliferation because they address the wrong variables. The endless proliferation seems to be caused by national bureaucratic forces rather than international threats to our security. Therefore, international agreements may not be the optimal method for arms control unless their provisions aim at putting certain classes of weapons systems beyond the reach of domestic military bureaucracies and organizations. Mr. Newhouse's book portrays vividly—and instructively—the adversary relationships of these organizations with the political leadership of the country. It leaves one with the impression that the real S.A.L.T. negotiations did not take place between the Russians and the Americans but between the political leadership and the military of each country; and for that alone the book is worth reading.

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Radiation: Past a Place to Turn

Silent Slaughter
Joel Griffiths and Richard Ballantine
Chicago: Henry Regnery Co.,
1972, 228 pp., 6.95

Reviewed by Dr. Franklin D. Aldrich

"From ghoulies and ghosties,
long-leggity beasties,
and things that go Bump in the Night—
Good Lord, deliver us."

Ghoulies of radiation, both ionizing and electromagnetic, are the silent killers baited by Mssrs. Griffiths and Ballantine, two freelance journalists. Our authors have garnered a feast of lore about stray radiation, from x-rays to lasers, and served it up with considerable alarm.

We are, of course, awash in radiation from within and without. We are bombarded by cosmic rays and terrestrial radiation, over which we have no control, and by gamma and beta rays, and alpha

particles from nuclear fallout over which we might have more control if, as our writers suggest, more stringent laws were passed and all government agencies were wholly impartial and committed to Truth. Interests are vested, lament Ballantine-Griffiths, and that is why we must fear cataracts from microwave ovens, cancer from isotope cocktails, and stillborn children from radioactive mine tailings upon which we build our homes.

This is the central theme in this book: human jeopardy arising from unwise, unwitting, or irresponsible uses of radiation.

Television Sets and X-Rays

We are first led through a saga of industrial nonchalance following the disclosure in 1967 that certain television receivers emitted as much as 800,000 milliroentgens per hour of x-irradiation at their chassis bottoms. The fact that children are more habituated to TV-watching than most adults, plus their proclivity for closer viewing distances, generated special concern for the possible harmful effects of cumulative x-irradiation on young, rapidly growing humans. The subsequent public furor led to enactment in 1968 of Public Law 90-602, wherein Federal standards were set forth to protect the public health and safety against unnecessary exposure to x-rays. As a result, the maximum permissible x-ray emanation from any television set is now 0.5 mr./hr. at a distance of five cm. from its surface.

X-ray machines and practitioners of x-ray are held to close accounting by Ballantine and Griffiths. One may (if one is old enough) well recall how one's foot bones wiggled in the eerie green screen of the shoe store's fluoroscope. This bit of pseudoscientific hucksterism, now mercifully gone, was responsible for irradiating not only the feet but also the innards and gonads of countless children and adults in bygone decades. What biological sequelae may have collectively or individually resulted from this indulgent radiological game, we may only guess.

It is now known that ionizing radiation, including x-ray, is carcinogenic (cancer-producing), mutagenic (mutation-inducing), and leukemogenic (leukemia-inducing). If the dose is of appropriate strength and duration and the target organism or tissue is radiosensitive, the biological outcome is nearly predictable. Epidemiologic studies of a large sample of medical radiologists, who use x-ray daily throughout their professional lives, have shown that leukemia incidence was seven times that in a comparable group of physicians who did not use x-ray in their work. Non-leukemic malignancies were 70 per cent increased in this same x-ray exposed group.

Radiologic technicians, who nowadays do most of the actual manipulating of x-ray apparatus and actually take the films which the radiologist later interprets, have had the benefit of no similar epidemiologic scrutiny.

Old, poorly-shielded, misadjusted, and noncollimated x-ray machines are still in daily use in many doctors' offices and dentists' suites. Only since 1968 have regulations been in force to limit excessive exposure of patients and x-ray personnel. Local and state governments, in the main, have been charged with monitoring equipment and enforcing these regulations. With a few notable exceptions, the laws go unenforced. Griffiths and Ballantine praise the radiation protection programs in Suffolk County, New York, and Pinellas County, Florida, hailing them to be the model programs they appear to be. But these, like many other county radiation survey operations in the country, are chronically short of qualified help and are able to plug only a few leaks in the x-ray dike.

Reactors, Microwaves, and Lasers

The current hassles over the siting and use of nuclear reactors will rage long and hot because, quite apart from the potential environmental impact these operations threaten, the question of nuclear contamination of air and water persists; so does the doomsday threat of a catastrophic accident. The Enrico Fermi Reactor near Detroit suffered a partial fuel meltdown in 1966. If this process had not been successfully checked in time, there would have been a likely loss of more than 100,000 lives. The fast-breeder reactor, of which the Fermi was the prototype, literally makes more plutonium fuel as it runs. No matter how carefully containments and fail-safe mechanisms may be planned, there will always lurk the possibility of atmospheric contamination by plutonium or with other nuclides in amounts potentially harmful to health. The situation is not like that of cyanide, of which one dose is enough, immediately. Radiation effects are cumulative; continuous, repeated exposure to small doses, particularly to internally-deposited isotopes such as ^{125}I, ^{239}Pu, or ^{90}Sr, produce biological effects discernable only after several generations have passed.

A classical assessment of the effects of internally-deposited emitters in humans is the on-going study of former radium dial painters and of persons who 30 or more years ago were given a variety of radium-thorium concoctions for one or another illness. Many such individuals survive today, having had their radiation-induced cancers "cured," but many also have succumbed to characteristic malignancies of bone traceable to the presence of skeletally-incorporated radioactivity.

The newest ghosties in our radiation closet are those of microwave and laser origin. It is true that high-energy microwaves can induce ocular cataracts and that laser beams can, at the least, cause injury to the retina. We are just coming now to understand more intimately the nature of these energy sources and to set rational guidelines for their use and for protection of human health.

These experiences and others which will be familiar to readers of this magazine suggest how wary we must be of commitment to any new technological course without second-guessing even the remotest possibilities for untoward second-order effects. Our authors, Griffiths and Ballantine, say this in many ways and cite numerous examples to illustrate their case.

Silent Slaughter is one of several similar books which alert us to the dangers of radiation. Rachel Carson and Ralph Nader would applaud its message and style, but I submit that we have already gone so far down some of the paths *Silent Slaughter* decries that we need only to wait for future developments in order to assess the validity of its authors' arguments.

Is magnetohydrodynamics economically feasible, anyone?

Dr. Franklin D. Aldrich is Assistant Medical Director at M.I.T., in charge of the Environmental Medical Service

Letters

Continued from p. 4

the presence of noise resembling wind, rain, rushing water, or interfering conversations, etc. I realize that the design of such a test is formidable if the experimenter is to avoid possible bias, but I feel that this approach must be taken if we are to begin to truly know sensory system capabilities. Processing performance seems about as pertinent as applying a CW signal to the radar receiver designed to detect a coded return from the planet Mars!

My favorite example of a well-designed detection system is the eye. There are other potential means for locating and identifying objects in one's surroundings: bats and dolphins use active acoustic systems; many fish produce electric fields and have extremely sensitive detectors for the reception of perturbations caused by nearby objects; indeed, some sharks even detect and home-in on fields produced by their prey without themselves emitting signals.

No other system can compare with the eye for sensitivity, acuity, or perception over great distances. Consider first the detection system alone: The sun emits its peak power in the visible spectrum; the atmosphere has its widest band of transparent wavelengths at precisely these frequencies. The energy of these visible photons is sufficient to directly excite organic dye molecules yet low enough not to destroy them. The physical dimensions of the wavelengths are small enough so that suitable structures capable of extremely high resolving power are possible without compromising the organism's size or agility. The dark-adapted human eye is capable of detecting the coincidence of only two or three photons; but, more to the point, the eye's overall dynamic range is exactly that which is required for use under all natural conditions, from a clear, starlit night to a bright sunlit day at the beach (approximately nine orders of magnitude). This remarkable detection system is followed by an even more remarkable signal processing system. Investigators have begun to uncover the rudiments of early processing steps, which seem to consist of abstracting operations looking for information in the form of lines, spots, edges, contrast, motion, etc.

It is only through the use of such tests as these—looking for the ways in which information is retrieved and processed from the sensory data stream—that we can ever hope to understand the remarkable beauty and power of the human senses.

Jay C. Sinnett
Alexandria, Va.

An Institute Informant

The Editors' digest of recent and current concerns at the Massachusetts Institute of Technology

Is Teamwork Possible for Health Care Teams?

Everyone concerned with the management of health care institutions in the U.S. seems to be counting on teams and teamwork to resolve the evergrowing problems of keeping us healthy at reasonable cost . . . professional managers, paramedics, nurses, bioengineers, doctors, and others all working together. But simply calling a group a team does not assure that it will behave like one, think Professors Richard Beckhard and Irwin Rubin of M.I.T.'s Sloan School of Management; so they are in the midst of a two-year program funded by the Robert Wood Johnson Foundation to develop guidelines and strategies for building effective teams for health care and delivery.

Preliminary materials have now been tested in several settings, and revisions are now being completed before field testing begins. The result will be some specific aids—materials, curriculum plans, and development programs—for administrators in community health centers, hospitals, and medical schools.

Resonance: the New Dimension in Concert Halls?

A vibrating tuning fork is hardly audible—until it is touched to a table-top.

. . . Fine for a tuning fork, but what about the effect of different "tables" on such musical instruments as cellos, designed to sit on end-pins when played? A wooden stage and a concrete stage—to cite the extremes—would make music sound very different, thought Daniel L. Nelson, a graduate student in mechanical engineering at M.I.T.; and he is now completing a doctoral thesis on the question. Like most theses, this one turns out to be a fundamental study rather than an applied one, and Mr. Nelson thinks his contributions to noise and vibration control may be more important than his contributions to concert music.

The President's and Chancellor's Goals: Permeability and Human Values

If the nation's principal problems are hard to define, drawing in so many issues that the role of each is hardly to be distinguished, so must be the response a broad and flexible one.

And so it is, write the President and Chancellor of M.I.T. in their annual report for 1972-73, that flexibility is increasingly a source of strength—if of confusion—at the Institute.

"A striking feature of the activities of M.I.T. during the past year," write President Jerome B. Wiesner and Dr. Paul E. Gray, "is the growing permeability of the boundaries between departments and schools. . . . The intellectual questions which most stimulate members or our faculty and students are ones which require the collaboration of scholars from more than one discipline."

The same flexibility has resulted in blurring the boundaries between M.I.T. and other groups in our society, and Drs. Wiesner and Gray applaud this, too, as an example of the Institute's response to a larger social issue. No institution today, they say, "can operate unilaterally in its own realm, passing on to another or just ignoring the pieces of a problem which seem not to fit its traditional jurisdiction."

Flexibility also extends increasingly into educational programs—and even to the essential definition of education through requirements, electives, and off-campus opportunities. And this, think Drs. Wiesner and Gray, may be the most important dimension of all: "No single task is more crucial to our future than the preservation, in generations to come, of a first-rate student body with whom we can participate in the intensely human and personal process—not of teaching them our knowledge—but of helping them to explore the thresholds of their own minds, to develop their full intellectual powers, and to become strong, independent, self-reliant adults."

Beyond education and research, and beyond the obligation to anticipate for society the results of these, write the President and Chancellor, is a penultimate responsibility: in the era of Watergate, we must try to "demonstrate ultimate respect for the values and priorities of individuals—enhancing rather than restricting their opportunities for self-development and growth . . . to charge our intellectual and professional development, and that of our students, with an understanding and concern for the underlying questions of human values."

Finances: "Moderate Gains" in 1972-73 Are Offset by Gloomy Predictions for the Future

M.I.T. finished 1972-73 having "gained moderately in financial strength," according to its Treasurer, Joseph J. Snyder. The Institute turned to unrestricted current resources for $2.6 million during the year, leaving $1.1 million of those funds unallocated as the fiscal year ended on June 30, 1973. And $1.5 million of unrestricted funds from 1971-72 was set aside as endowment for professorships.

But there was no long-term optimism in a report to the faculty by Paul E. Gray, Chancellor of M.I.T. He said unrestricted funds may fall short of expenses by as much as $7 million in 1973-74, due to the sharply increased pressure of inflation and the loss of overhead through divestment of the Charles Stark Draper Laboratory, Inc. A new round of budget trimming will be required, and he fears the emphasis will be on academic budgets instead of those for administration and plant; to help soften the blow, the Institute will increase tuition by $250, to $3,350, effective with the 1974 summer session.

At best these will be temporary solutions to a problem which is predicted to continue indefinitely: expenses are rising faster than income each year by a margin of about $1 million; a budget balanced in one year is out of balance by $1 million the next and $2 million the year after that. The solution lies in two directions, Dr. Gray told the M.I.T. faculty: increase productivity and find substantial new funds.

New Research

Among new grants and plans announced at M.I.T. this fall: a study of the interdependence of nations, with special reference to the effect of the energy crisis, by Lincoln P. Bloomfield, Professor of Political Science in the Center for International Studies (for the U.S. State Department) . . . the environmental consequences of oil development on the outer continental shelves off the Atlantic and Alaskan coasts, by the M.I.T. Sea Grant Program for the Council on Environmental Quality . . . the legal and regulatory framework for mining in the coastal zone, a joint program of Professors Michael S. Baram of M.I.T. and David A. Rice of Boston University for the National Science Foundation . . . research and teaching on arms control and national security policy, a $500,000, four-year grant from the Ford Foundation . . . an economic and technology study to identify alternatives for development of the drought-stricken sub-Sahara nations of Africa, a $950,000 program in the Center for Policy Alternatives . . . to give plastics and polymer processing, a "typical 'fragmented' industry of small companies,"

more leverage on research and development, Nam P. Suh, Associate Professor of Mechanical Engineering at M.I.T., proposes a pilot program for doing industry-needed work in academic laboratories; he hopes to have done $1 million of work in five years, with half of the funding from industry, the other half from government, and the National Science Foundation has made a $100,000 commitment for the first year . . . a Northeast Academic Science Information Center, with headquarters at M.I.T., to make information and bibliographies available in machine-readable form, eventually drawing on library resources of Atlantic-seaboard states as far south as Delaware.

A Distinguished Visitor

Pierre R. Aigrain, whose role as the French government's General Delegate for Research and Technology makes him in essence the science adviser to the French Prime Minister, is the first Henry R. Luce Professor of Environment and Public Policy at M.I.T. He is Professor of Physics at the University of Paris, a distinguished contributor to solid-state physics, semiconductors, and energy conversion as well as to science policy and other public issues.

Is M.I.T. Coed? It Is Indeed; And Other New Fall Registration Records

When the dust settled atfer the hectic first weeks of the Fall Term, M.I.T. decided that 7,580 students were registered—4,061 undergraduates, 3,233 graduate students, and 286 special graduate students. Included in the total are 850 women, more than ever before.

The freshman class stood at 893—the smallest in more than 10 years. Housing problems—composed equally of a housing shortage in Greater Boston and an unprecedented demand for on-campus space by upperclassmen—dictated the small freshman class. Of the first-year students 122 are women—the highest proportion (15 per cent) in M.I.T. history. The 771 men is the smallest total of males to enter M.I.T. since the years of World War II.

Contrary to expectations, Graduate School registration was a few percentage points higher than last year. Entering graduate students included 60 from minority groups, bringing the total of minority graduate students to 136—a new high.

New Arrivals

Two notable visitors among many who will teach and study at M.I.T. in 1973-74:

—Secor D. Browne, former Chairman of the Civil Aeronautics Board, is Visiting Professor in the Department of Aeronautics and Astronautics, giving seminars and planning studies in air transportation.

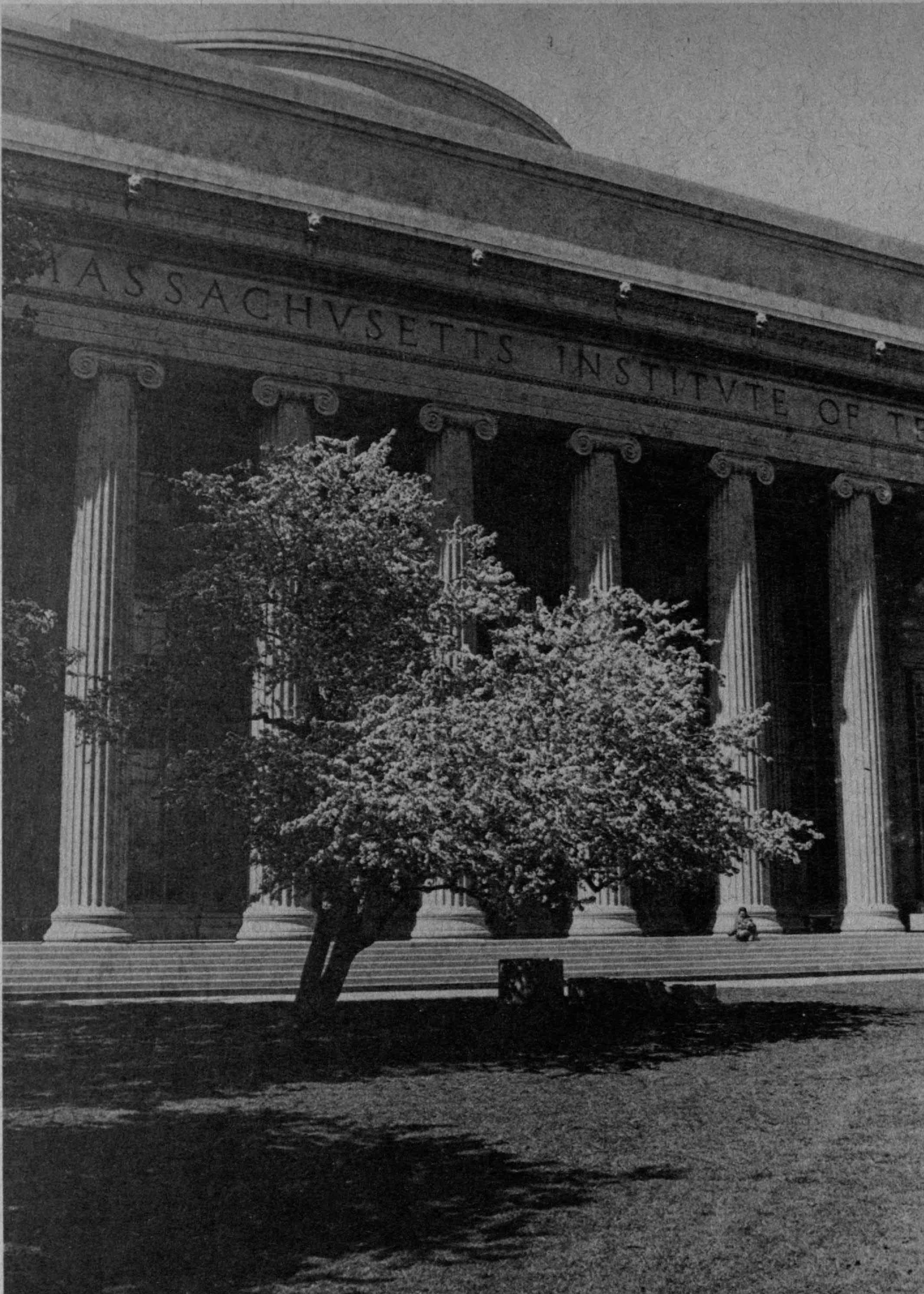
—George B. Kistiakowsky, Professor of Chemistry, Emeritus, at Harvard who was Science Adviser to President Eisenhower, is Visiting Scholar in the Center for International Studies, working on the international policy implications of technological change.

REPORT OF THE PRESIDENT AND THE CHANCELLOR

FOR THE ACADEMIC YEAR

1972–1973

MASSACHUSETTS INSTITUTE OF TECHNOLOGY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INTRODUCTION

Last fall we described our first year in the stewardship of M.I.T. as simultaneously a period of taking stock, of getting acquainted with new responsibilities, of gathering momentum for the ongoing activities of the Institute, and of seeking new directions. Those new directions, largely new syntheses of ongoing activities such as work in energy technology or economic modeling, are intimately related to the major challenges so urgently facing our nation—the necessity of using technology with greater prudence and insight; the necessity of getting more of our technical manpower into some of the mature industries; the necessity of finding ways in which increasingly complex and interlocking bureaucracies can work together on behalf of people; and the necessity of redressing inequities in opportunity for women and minorities. Today's challenges to the nation are challenges to M.I.T., if it is to continue to set the style and pace of technical and scientific education. Moreover, during the past year, as we have thought more deeply about these problems and have worked toward their solutions, we see more and more that they are not unexpected new cliffs to be scaled with one mighty effort, but are related to old problems whose solutions we know something about, and are, therefore, more like gradual slopes, attainable bits at a time through sustained and purposeful work.

In some respects, the most newsworthy report about the past year should be that it was, after all, a *regular* year. There were, as in any year, moments of concern, of crisis, and even of exhilaration, but, by and large, we were not subject to the dramatic swings of mood of the late 1960's or to the tentativeness which must dominate the first year of a new administration. This year the daily tasks of the Institute, mundane in many respects and quite ordinary when viewed at the end of each day, added up, we like to think, to a year of significant achievements. The familiar bustle of the M.I.T. campus gave evidence that students and faculty alike were engaged in activities that challenged them, stretched them perhaps just a little more than they had expected, and gave them the opportunity to share with each other triumphs, disappointments, frustrations, and hopes. If there is any pervasive problem on our campus today, it is that all of us, faculty, students, and administration alike, are extending ourselves too far; but this is hardly a new problem for M.I.T.

Much like the several years which preceded it, the past year was one in which financial aspects of the Institute's present and future educational operations demanded a major portion of our energies and efforts. The press of inflation on operating costs continued and even increased during the year, therefore making more difficult the twin tasks of controlling ongoing costs and reallocating resources in accordance with the changing complexion of the academic enterprise. The outlook for the near-term future suggests that unrestricted income, particularly unrestricted gift income, will continue to play a crucial role in the support of educational programs. Clearly we must continue to give high-priority attention to cost reduction efforts and to the development of new research and academic programs which will generate additional operating revenues.

While the year had a welcome normalcy about it that many recent years have lacked, there were many new activities, shifts of emphasis, and changes of process which made this year simultaneously unlike earlier ones, as well as a continuation of the familiar history of this remarkable institution. The annual reports of our colleagues, the Provost, the Deans and department chairmen, the vice presidents, and the laboratory and center directors, review the year's events and accomplishments in detail. We can trace in them the growth of familiar and new activities, growth that is extracted from an ever tighter budget. Exciting and responsive to perceived needs, these activities represent not a revolution or an overnight transformation of the Institute into something entirely new, but, as already indicated, the gradual absorption of concerns and fruition of hopes which have been building for several years. It comes down to a myriad of small details—teaching a subject just a little differently than before or creating a new one, discussing just a bit more seriously some new activity on the horizon, doing the long and arduous work of turning an idea into a reality. Faculty and students in all parts of the Institute are caught up in these tasks, thereby creating a climate in which M.I.T. will be able to meet the unique and changing challenges of the present and of the years to come.

M.I.T. has always been an institution intimately connected with the fabric of the larger society—with its problems, its achievements, and its challenges. At a time when our country was rapidly industrializing, the Institute, even in its infancy, was a major source of industrial and technological strength and of a new breed of professionals to work in the new industries. M.I.T. today retains strong links to industry, through its management programs, its research into new industrial processes, and its collaboration on the solution of a variety of special technical problems. In fact, the nature of today's problems is bringing many new links to industry.

During and after World War II, when pushing back the frontiers of scientific knowledge and applying these advances was an increasingly important goal of our nation, M.I.T. was one of the leaders in that endeavor and has remained one of the most important national and international contributors to the advancement of scientific knowledge. Efforts, begun years ago, to explore the structure of the atomic nucleus, to understand and expand the theoretical framework for the physical properties of materials, and to order the structure and processing of information are continuing with vigor, contributing major components of the ongoing intellectual activity of the Institute. Now, when astrophysics, the earth sciences, the biological substrates of life, the battle against disease, and the concern for increasing the nutritional value of the earth's agricultural production take their places alongside older scientific challenges, M.I.T.'s faculty and students find themselves adding those issues to their list of interests and helping to develop the related sciences which will enable us to better understand the world in which we live.

Therefore, it is probably less accurate to say today that we see a radically changing M.I.T. than to say that we see the *same* M.I.T. addressing and dedicating itself to the changing

Students relax on the steps of the Julius A. Stratton Student Center.

issues of the times. These issues continue to involve newly visible and often extremely complex threats to the human environment and the society of which we are a part. We continue to believe the point we stressed last year: that if in the 1970's M.I.T. is to continue to serve a world highly dependent on science and technology, our goals must be to enhance our traditional scientific and engineering disciplines and to provide the research settings and learning opportunities which can effectively meld the technical, the scientific, the social, and the humane. We must do this, not at the expense of our scientific and technical work, but in addition to it. In a report such as this, we are tempted to concentrate on change—on the new. Partly, there is so much continuing activity that it is impossible to do it justice in so brief a space. Any impression that all is in flux at M.I.T. should be quickly denied. It is the stability of the departments and laboratories which provides a steady momentum for the Institute, which sustains it and supplies the vitality on which we draw when beginning new activities.

RESEARCH AND EDUCATION—INTERNAL COHERENCE

As we examine the activities of M.I.T. in the past year, a striking feature is the growing permeability of the boundaries between departments and Schools. This is perhaps a response out of necessity, both intellectual and financial. More than ever, the intellectual questions which most stimulate members of our faculty and students are ones which require the collaboration of scholars from more than one discipline. The temptation is to hire all of the needed expertise in each department, for example hiring physicists in Electrical Engineering, economists in Mechanical Engineering, etc. Some of this is necessary in order to provide adequate intellectual support within departments, but we cannot afford much such duplication, and we work hard to avoid it. In both research activities and educational programs, groups of people already here form around mutual interests, creating a network of activities which cuts across traditional departmental and School organizations. Although often puzzling to newcomers or to those who have been away from the Institute for a time, these interdepartmental ad hoc groups which spring up resonate with each other, with the departments and Schools, and with corresponding groups outside the Institute. Through these working relations, they invent new ways for the Institute to address particularly complex and changing intellectual issues. Some fear that such coalitions provide only superficial ties, however, we have found that they are often conducive to fundamental regrouping among disciplines. Such intellectual syntheses can generate truly new and powerful perspectives, which can drive future collaborative work and also feed important new paradigms back into the component disciplines. Interdisciplinary collaboration and integration is as important in the basic sciences as in applied fields. One need only recount the great discoveries in biochemistry, biophysics, astrophysics, and neurophysiology to recognize the validity of this point.

These processes, in which new coalitions of faculty and student activity emerge out of the press of new problems that transcend or confound disciplinary and prior organizational boundaries and form new entities, have been evident at the Institute for many years. More than 25 years ago the Research Laboratory of Electronics set the style for this process. More recently the Center for Materials Science and Engineering, the Sea Grant Program, the joint Harvard-M.I.T. Program in Health Sciences and Technology, and the Center for Policy Alternatives have provided additional examples of the role of interdisciplinary academic research enterprise at M.I.T.

Several additional areas of interdisciplinary research, each pursued by diverse faculty and student groups for a number of years, have gradually been coalescing. This year we note the evolution of some of these to formal research organizations at the Institute. Especially important at this time is a new special laboratory, which was formally established in February, 1973, to address energy related issues. The Energy Laboratory will draw together existing energy research programs with a total annual volume of $5 million and will augment these programs with long-term interdisciplinary projects of considerable magnitude. A significant number of faculty members, research staff, and graduate students are involved for at least a part of their time, representing work done in each of the five Schools—the several disciplines in engineering, science, the social sciences, management, and planning. Professor David C. White of the Department of Electrical Engineering is the Laboratory's first Director. We are currently engaged in seeking new funds to support this activity. We want to see it become a major M.I.T. center.

On a somewhat smaller scale, the Center for Transportation Studies, newly established within the School of Engineering, is comprised of an equally broad spectrum of disciplines and is dedicated to research on transportation and systems' planning and operation. The Center provides a focal point for the Institute's various transportation research programs and will help coordinate this work with related efforts undertaken by other agencies in the Greater Boston area.

Growing out of M.I.T.'s distinguished research in molecular biology, a Center for Cancer Research directed by Professor Salvador E. Luria was established this year. In December, 1972, we received substantial grants from the National Cancer Institute for support of the Center's research program and from the Seeley G. Mudd Fund for construction of a new building to house the Center. A number of other grants are being pursued to augment the existing support. We are in the process of assembling a distinguished group of biologists and cancer researchers to work with Dr. Luria, as well as building necessary facilities; and we expect that, with scientific work commencing during the next year, the Center will be in full operation by the fall of 1975. This continues the emergence of M.I.T. as a significant participant in the health sciences, adding to our work in fundamental biology, nutrition, neurophysiology, the many aspects of bioengineering, and the joint Harvard-M.I.T. Program in Health Sciences and Technology.

The several new organizations mentioned above provide the institutional settings for more fully supporting and facilitating research activities carried on for some time by many members of our faculty and for augmenting these activities in a variety of ways. Similarly, during the past year an interdisciplinary

faculty Steering Committee has been meeting to plan and to put into operation a Division for Study and Research in Education. For a number of years there has been much interest in better understanding the nature of undergraduate education at M.I.T., as well as a number of inquiries on the part of several distinct groups of faculty members into more general aspects of the educational process—learning theory, mid-career education, the potential of educational technology, curriculum development for schools, etc. The Steering Committee has proposed an organizational entity which would provide the opportunity for specialized and professional research in education, for augmenting and giving focus to our discussion of our own educational processes here at M.I.T., for utilizing components of earlier activities such as those of the Education Research Center, and for students to pursue their interests in this field. The Division will ultimately have several intellectual focal points. The first, which is already the driving force behind several graduate and undergraduate subjects, is a variant of learning theory which will explore the hypothesis that the learning process proceeds through successive model-building. The Division began its formal existence on a modest scale on July 1, 1973, with Professor William T. Martin as its Director. Those curriculum development programs and other activities of the Education Research Center which were not incorporated into the new Division either have been made part of other groups or have been phased out.

A major change in the research scene at M.I.T. is the change in status of the Draper Laboratory to a fully independent organization dedicated to scientific, engineering, and educational activities. On July 1, 1973, the Charles Stark Draper Laboratory, Inc. was formally established, after nearly 40 years as an integral part of M.I.T. Three years ago, as we anticipated this separation, M.I.T. appointed an independent Board of Directors for the Laboratory to guide its transitional phases. That the divestment has been accomplished so successfully and the laboratory begins with a solid footing is a tribute to the efforts and interests of many people but is notably due to the perceptive and energetic work of those who served on this Board, many of whom continue on the Laboratory's Board of Directors: Dr. Albert G. Hill, Chairman; Dr. Robert Charpie; Dr. C. Stark Draper; Gen. Robert A. Duffy (Ret.); Adm. John T. Hayward (Ret.); Dr. Carl Kaysen; Gen. James McCormack (Ret.); Prof. Charles L. Miller; Mr. Alan Pifer; Dr. Emanuel Piore; Dr. Robert C. Seamans; Mr. David W. Skinner; Mr. Robert C. Sprague; Dr. Julius A. Stratton; and Mr. Mark C. Wheeler. Formal arrangements assure continued close ties between M.I.T. and the Laboratory, and we expect that its work in its traditional areas of inertial guidance, and navigation and control systems, as well as new activities in other areas such as industrial automation, medical instrumentation, etc., will continue to enrich the intellectual life of both faculty and students at the Institute.

As growing numbers of the faculty collaborate in research projects throughout the Institute, their activities act as incubators for new educational ventures which flourish both within and across departmental boundaries. Undergraduate education, or, more precisely, the presence of undergraduate students, has been, since the inception of the Institute, the strong unifying influence that brings together diverse interests and intellectual activities. This year has been no exception, and the pulse of the undergraduate academic calendar can be said to set the rhythm for almost all who study and work at the Institute.

Over the past several years the faculty has initiated a number of innovations in undergraduate education—some affecting undergraduate education in general, others relating specifically to the freshman year. During this past year, several of these experiments came to the faculty for evaluation and for decisions regarding their future. The faculty voted to continue the January Independent Activities Period as a regular feature of the academic calendar. In a spring Faculty Meeting there was a decision to continue the Wellesley-M.I.T. Exchange Program, which expands the educational and cultural opportunities available to students at both colleges. In doing so, the faculty acknowledged that the Program has highlighted certain questions relating to the education of women at the Institute and resolved that increased efforts should be made to recruit more women students and faculty and to portray M.I.T. and its educational programs as open and suitable for both women and men. With regard to the first year program, the policy of grading all first year students on a pass/fail basis was approved for continuation, with the understanding that outstanding performance would be identified clearly in the evaluation of students' work, that failing grades would be kept on the internal record only, and that there would be a limit on the number of credit units taken by freshmen. Two of the special freshman programs were continued for a period of three years. Concourse and the Experimental Study Group were recognized as providing both valuable opportunities for freshmen to select curricular options and educational styles suited to their interests and needs and important foci of activity and support for those people interested in educational innovation in the freshman year.

Throughout the year consideration of these issues was guided by the work of the faculty Committee on Educational Policy, chaired by Professor Hartley Rogers, Jr. As Chairman of the faculty, as well as of the Committee on Educational Policy, Professor Rogers brought a special measure of commitment and thoughtfulness to matters bearing on the nature and quality of education at the Institute. In the coming year the Committee, with Professor Elias Gyftopoulos as Chairman, expects to consider further the definition of the unique features of an M.I.T. education—a task of increasing importance at a time when students and their families question, understandably, whether the programs of private colleges and universities are worth the high tuition costs.

To date, the numbers of students who are attracted by our programs, together with their enthusiasm, is a continuous demonstration of the intellectual vitality that characterizes the faculty's involvement with undergraduate education. This is especially obvious in the fall when a new entering class registers for the freshman subjects in the basic sciences and the humanities or for one of the special programs. The success of these programs—whether they represent a means to integrate

and package the freshman year's studies or to provide a rich array of choices in electives—continues to make it easier for faculty to address the diverse interests and needs of students within a first-year curriculum, which attempts to maintain the logic and coherence of its more monolithic predecessors. The multiple choices in introductory physics, mathematics, and chemistry, discussed in previous years, illustrate this point.

In the upperclass years there are equally varied options for study within departments and Schools and in programs which combine the disciplines in more than one School. In addition to the departmental programs there are the multidimensional opportunities which include: the interdisciplinary major in the School of Science, the Undergraduate Research Opportunities Program, the Program in Health Sciences and Technology, the many programs linking technology and social policy, and the diverse selections in environmental studies, education, and law. Of particular note is the very large increase of student interest in the life sciences, including biology and the various health related activities. The versatility of a scientific or technical education is demonstrated by the growth of student interest in such fields.

In the field of law, for example, roughly 260 students were enrolled last year in 15 law-centered graduate and undergraduate subjects offered by 11 different departments. Enrollment in these subjects has more than doubled in the last five years, and an equal number of students has also been involved in individual research projects or field work. This widespread and diverse interest has sparked a response in the form of an Advisory Group on Law-Related Studies which has met during the year to assess the nature of student interest, to investigate the best ways for M.I.T. to respond to that interest, and to explore the professional interface between the study and practice of the law and a wide variety of technical fields, with an eye to contributing to the Institute's efforts to provide a more multidimensional education for the technical professional.

The number of interdepartmental and multi-School educational programs is too large to enumerate all of them here. Many of them such as the Undergraduate Research Opportunities Program, the several cooperative programs, and an increasing number of research activities are seeking closer links with industry. One particularly novel approach is the five-year funding at a level of $1.1 million by the National Science Foundation for a series of subjects to foster the invention, development, and distribution of new products. Students who produce working models of new devices will have those products licensed out to industry. Professor Y. T. Li originated the idea, and during the next few years the program will be conducted jointly by the School of Engineering and the Sloan School of Management. The program is intended to be income-producing, with the hope that it can be self-supporting after the initial five years. As an organized training ground for innovators and entrepreneurs, the program will be a supplementary cross-disciplinary educational system with an emphasis on learning-by-doing.

We have tried to show that in both research and educational programs the cross-disciplinary work which many serious problems of our time demand *can* be fostered at M.I.T. Students and faculty alike want to find ways to join together and to bring into the academy itself the issues and problems that most puzzle and concern all of us as we work and live in America in the 1970's. Interest in adding to man's store of knowledge and interest in applying such knowledge for useful purposes thrive side by side and challenge equal numbers of faculty and students. The response of the Institute has been in part—and remains—the invention of new ways to combine talents in research groups, centers, laboratories, and divisions. This response is one which has emphasized the unity rather than the diversity of M.I.T.; for the most part we have found strength rather than divisiveness in the variety of intellectual resources available here. The most encouraging news that we can report for this year is that a large portion, if not all, of M.I.T. is involved in both the emergence of dynamic combinations of people around challenging ideas and the invention of organizational forms to nurture them. In this way we hope that M.I.T. will remain a vital intellectual resource for our nation.

RESEARCH AND EDUCATION—EXTERNAL COLLABORATION

While much of the recent effort in response to engineering and socio-technical challenges has the characteristic of transcending traditional disciplinary boundaries within the Institute to create a flexible working environment, it also seeks to a considerable degree, to disregard boundaries between the Institute and other groups in our society. This is appropriately so, for the Institute has traditionally demonstrated its willingness and ability to address issues presented by outside "clients," or collaborators, as the case may be. The sharing of problems and perspectives among many kinds of institutions, the university among them, is particularly necessary in an era when very large organizations in all sectors—private enterprise, government, and academia—must make decisions which will effect the quality of life for all of us. It is no longer possible for each to operate unilaterally in its own realm, passing on to another or just ignoring the pieces of a problem which seem not to fit its traditional jurisdiction. The system in which we live and function is too large, too complex, and too interconnected for this to be a safe mode of behavior. Each organization must stretch its own definition of what it is competent to do, so that among us we can accept the responsibility for directly meeting major and extremely elusive problems of our time.

Among universities, M.I.T. is in a particularly good position to do this. With its long tradition of pursuing knowledge which is "useful," and with its many relevant competences including those in the social sciences and the communication and computer sciences, M.I.T. is joining other groups in our society in the search for solutions of problems which depend on new kinds—or at least new mixtures—of knowledge. Of equal importance is our leadership in the training of new professionals who can work on these problems as they exist in the world.

While a commitment to the larger society motivates the work of many people at M.I.T., arranging effective couplings

to appropriate groups outside the Institute turns out to be a difficult task about which we still have much to learn. However, the work of a group of faculty, conducted under Energy Laboratory auspices, on modeling natural gas supplies had a major effect on national policy. A Sea Grant program examining the economic and ecological consequences of Alantic offshore drilling may be similarly effective. Another such effort, reported last year, was the chartering of the M.I.T. Development Foundation, Inc. to stimulate the process of innovation and to quicken the transfer of technological advances from laboratory to general public use. This organizational experiment has had an intensive first year during which a core staff has been brought together. In addition, the many complicated policy issues, arising in the areas of patent licensing and new enterprise development where M.I.T. is involved, have been faced. As the year ended, three separate areas of new technology capitalizing on technical advancements in, respectively, magnetic separation of materials, long-wearing cutting tools, and the die-casting of non-ferrous alloys, seemed well on the way toward embodiment in new or reorganized companies.

Another new project which will begin in the fall of 1973 is a prototype program for university based research and development organizations designed to serve specific industries. With a grant from the National Science Foundation, Dr. Nam P. Suh of the Department of Mechanical Engineering will be directing a special program to collaborate on R & D with several companies in the plastics processing industry—an industry consisting of many small companies whose size makes it difficult to support expensive research and development processes. The research and development work done in this prototype program and others which might follow it should be of help not only to the cooperating industries but also in the training of graduate and undergraduate students at M.I.T. for careers in related professions.

Similar instances of M.I.T.'s collaboration with "outside" groups, to the mutual advantage of all, are occurring at an increasing rate throughout the Institute. For example, those groups that will make up the Division of Health Sciences, Technology, Management and Planning (which is in the process of formation) are collaborating not only with the Harvard Medical School but also increasingly with the Harvard teaching and otherwise affiliated hospitals. Out of this cooperation are emerging rehabilitation centers and, hopefully, hospital departments of medical engineering.

Furthermore, many students have been participating in a variety of field work programs which add the dimension of "real world" problems to their studies, simultaneously providing much needed staff assistance to financially constrained local governmental agencies—members of the Massachusetts Legislature, members of the Cambridge City Council, and advocacy groups working on behalf of the elderly, the handicapped, or the poor. Most such efforts have multiple goals—providing opportunities for students to integrate "book learning" with the fuzzy multi-dimensional questions which face most professionals and providing a host of connections from the Institute to the society in which it lives. Many of these con-

Walter L. Milne, Special Assistant to the President for Urban Relations, speaks at the open house of new public housing for the elderly in Cambridge, a major project developed and built by M.I.T. under the Federal Turnkey program.

nections have been developed through the initiative of individuals, very often students, each inventing his or her own way to combine responsibilities to the Institute with responsibilities of citizenship.

A major project, just nearing successful completion, represents a very large institutional commitment to the Cambridge community in which the Institute is set. That project has involved building, for sale to the Cambridge Housing Authority, 684 units of public housing for low-income elderly people. The completion of this housing on three different sites in Cambridge caps a four-year $17.1 million program M.I.T. initiated to help ease the acute housing problem for the elderly in Cambridge. This housing has been developed and built under the Turnkey mode, through which a private developer independently acquires land, plans and constructs the buildings, then conveys them to the local housing authority. Once they are conveyed, M.I.T. will have no continuing operational or financial interest in the properties.

This M.I.T. development is believed to be the largest Federal Turnkey program in the country. Each of the three complexes was designed specifically for its neighborhood after extensive consultation with neighborhood residents and with representatives of the elderly themselves. The opportunity of working in close cooperation with residents of three different neighborhoods and with a city-wide committee of elderly people on the planning of these developments has involved M.I.T. more intimately with the citizens of Cambridge than has any other project the Institute has ever undertaken. One result, as a by-product, has been improved relations with the city.

In addition to apartments, each of the new buildings contains extensive common facilities for use by the residents (and, in some cases, the neighborhood) for extended living, for activities, for health and other services. From the beginning of its planning, the Institute recognized that good housing alone does not solve the problems of low-income elderly people. Therefore, M.I.T. has made every effort to mobilize community resources so that supportive services will be available to the tenants when the buildings are occupied.

The purpose of these efforts has been to develop a comprehensive and integrated plan of supportive services that will help sustain the elderly in independent living as long as possible. This goal has led to a number of associated projects—some involving faculty and students in field-linked activities—in areas of health, employment, transportation, and the like. One student, for example, helped establish a sheltered workshop for the elderly that may be unique in the country. Other students developed a share-the-ride taxi experiment for the elderly, in which they took total responsibility for the design of the experiment and its implementation. All told, we view the accomplishment of this total program with utmost satisfaction.

ENVIRONMENT FOR LIVING AND LEARNING

During the past year considerable national attention has focused on the grisly details of the Watergate and related events—events caused basically by an arrogant use of power. Being foremost in so many aspects of Western civilization is an awesome responsibility for our nation—a responsibility which often has been discharged with compassion, a stance of genuine responsiveness, and a deep hope for the alleviation of plagues and troubles. Unfortunately, it is sometimes the case that responsibility is discharged with false humility, self-aggrandizement, and the single-minded certainty that might makes right. Each generation must earn its right to the benefits of a free society—nature does not ensure either our democratic freedoms or our social progress. We have seen how fast a society can lose its momentum and idealism when they are taken for granted.

As an institution of international reputation, a source of both scientific and technical knowledge and of experts in related fields, M.I.T. faces a challenge similar to that of our nation as a whole. We must responsibly manage the influence which we irrevocably have on national affairs, on the local community in which we reside, on those who spend much of their working lives here, and, above all, on those who are educated here. The responsibility is inescapable, but we can choose the ways in which it will be discharged. Our activities as educators, researchers, and citizens can be expedient and self-protective, or they can demonstrate ultimate respect for the values and priorities of individuals—enhancing rather than restricting their opportunities for self-development and growth. Now is the moment to try a little harder, to care a little more, to charge our intellectual and professional development, and that of our students, with an understanding and concern for the underlying questions of human values. At M.I.T. we are assuming this responsibility in a number of ways. We teach some of the science and engineering subjects with an historical perspective. We have subjects that examine the moral and legal implications of what we do. We have programs in which people from engineering, science, and the arts explore together the aesthetic possibilities and social implications of these various disciplines. However, it is not enough to confine this responsibility to the classroom. None of us has the answer, but we are working together—trying to create an environment for living and learning which is forged from the deepest commitment to human dignity, from a sense of beauty, a sense of humor, and a thoughtful and compassionate perspective on the world in which we live.

Among those engaged in this work are many members of the School of Humanities and Social Science. The first few months in the Deanship of Harold J. Hanham has been a period of Institute-wide discussion on a wide range of issues, among them the social interfaces of science and technology, the existing state and possible future shape of the undergraduate humanities requirement, and the possibility of pioneering a new type of social history of modern technology. Such discussions have pointed up the School's two complementary missions: 1) to study the human condition and the values which define our social institutions and artifacts by exploring history, art, literature, music, and philosophy; and 2) to describe human artifacts, social institutions, brain and intellect by using the tools of economics, social science, psychology, neurophysiology, and linguistics. Each in its own way provides additional insights into our hopes, fears, and attempts to build

a satisfactory society. Together with the scientific and technical skills which M.I.T. students develop, these insights can uniquely prepare M.I.T.'s graduates to provide leadership, and perhaps even wisdom, in today's complex and confusing world.

Last year we reported the establishment of a Corporation Visiting Committee on the Arts and a Council for the Arts at M.I.T., both to foster interaction between the extraordinary range of artistic activities housed in the departments and Schools and to develop a constituency among alumni and friends for activities in the arts. An increased visibility for the arts at M.I.T. provides not only important recognition for the serious creative efforts of many people here but also raises more directly into the consciousness of all of us the visions the artist provides. For among the activities in which human beings engage—conceptualizing, forming organizations, forging complex tools, analyzing problems—it is perhaps in the arts that a uniquely *human* vision appears; and the best of that art often contains the most piercing statement of the human dilemma. Through art in its various forms we can, sometimes obliquely, sometimes incisively, provide a counterpoint to the analytic, the mission-oriented, the problem-solving set of mind and create a context in which all dimensions of the human spirit can grow in harmony.

A modest but notable achievement of the Council for the Arts was this year's national tour by the 97-member M.I.T. Symphony Orchestra. Performing in Philadelphia, Dallas, San Francisco, Los Angeles, and Chicago during the spring vacation, the orchestra's performances were acclaimed a great success by music critics, who most often were taken aback at the realization that a performance of professional quality was offered by musicians who were "really" potential electrical and mechanical engineers, physicists, and mathematicians. As Daniel Webster of *The Philadelphia Inquirer* put it, "It was apparent from the kind of musicianship in this orchestra that the Council for the Arts at M.I.T. is working with a true Renaissance spirit in which science and art were not disciplines to be separated or understood singly."

A very different and equally important contributor to the institutional climate of M.I.T. are those efforts toward increasing the employment opportunities for minorities and women and enhancing the mobility available to those who already work here. As we stated in last year's Report and reiterated in the Institute's Affirmative Action Plan, we must join with other institutions in this society to ensure that considerations of race, sex, and national origin are irrelevant as determinants of the access an individual has to opportunities for education, for employment, for achievement, and for personal fulfillment. Rather, the controlling factors in all such matters must be individual ability, interest, and merit.

The Affirmative Action requirements of the Federal government spurred us last spring to make explicit the procedures by which each of the more than 80 employing units of the Institute would make good this commitment during the next few years. The Affirmative Action Plan, submitted on April 6, 1973, was accepted by the Department of Health, Education,

The 97 members of the M.I.T. Symphony Orchestra rehearse prior to their widely acclaimed spring tour to Philadelphia, Dallas, San Francisco, Los Angeles, and Chicago.

and Welfare, and we now continue with the task of implementing it. While the thinking through of future staffing needs, the computation of likely numbers of female and minority applicants, and the determination of reasonable goals for the next few years took extraordinary effort and commitment on the part of every department and administrative unit, in a fundamental sense the accomplishment is only a *pro forma* one if we cannot maintain the energy and purposefulness required to make our promises into fact—to change the composition of the Institute's staff. Non-discrimination has been and continues to be the policy and long-range goal of the Institute. Affirmative Action programs are necessary short-range steps to achieve this goal. They are predicated on what we know to have been years, decades, perhaps centuries of practice that has tolerated bias, discrimination, and a treatment of people on the basis of stereotyped views and misguided convictions of what they want and what they are entitled to. Any community with the complexity and durability of M.I.T. has of necessity developed informal traditions, consensual images which provide coherence over time, and shared priorities regarding what kind of work is relevant and interesting. These attitudes were developed in us as we grew up in a society dominated by white, usually middle-class, men, were educated in their universities, worked in professions dominated by them, and found M.I.T. capable of supporting us in our continuing activities. Attitudes developed from such a history will not go away by virtue of a faculty vote or the forging of guidelines. We have ingrown institutional challenges that require much deeper understanding and commitment.

Of considerable help in encouraging us to face the pervasiveness of these problems has been Dr. Mary P. Rowe, appointed last winter as Assistant to the President and Chancellor for Women and Work. Her open door policy, providing a focal point to which complaints, suggestions, and frustrations can be addressed, has resulted in hundreds of women and men voicing their concerns about the conditions under which they study and work. The very existence of a sympathetic ear has shown us the depth and breadth of our troubles.

During the spring, the Commission on Minority Education—a group of faculty, students, and staff who worked during the previous nine months under the chairmanship of Professor Albert G. Hill—reported to the community concerning their view of the special problems which face minority students at M.I.T. They recommended that efforts be made to strengthen the sense of community among minority students and to facilitate access to the full range of educational and counseling resources that exist at the Institute. Efforts have now begun to bring into existence the Office of Minority Education which was recommended by the Commission.

Through the work of the Office of Minority Education, Dr. Rowe, and many others, we hope to gain a clearer image of what it means to create a truly human environment in which all people—students, faculty, and staff—can thrive as individuals, can take responsibility for their own lives, and can fully participate in the life of an educational organization which takes them seriously as individuals and not solely as the fillers of job slots or as "representatives" of "the women's issue" or "the black issue."

All of these enrichments of the institutional climate—creating settings in which social and technical values can be explicitly discussed and interrelated, creating an atmosphere in which the creative arts can flourish and contribute their special aspect to education, creating the opportunities for self-fulfillment and advancement for every member of our community even if that means subtly changing deeply ingrained attitudes—are ways of supplementing the analytical and investigatory skills so highly developed by students and faculty at M.I.T. A thorough infusion of such concerns into the lives of each one of us should allow us to proceed with our scientific and technical work buttressed with a sense of personal confidence, a firm sense of integrity, a respect for others, and the courage to pioneer and lead. We cannot take our scientific and technical prowess for granted—it needs close attention if M.I.T. is to contribute significantly to the solution of the pressing socio-technical problems of the post-industrial society. But such prowess will leave us on a shaky and narrow pinnacle if not combined in individuals with personal characteristics equal to the moral dilemmas of our time.

IN SPECIAL RECOGNITION

As in the past, the individual efforts and distinctions on the part of the faculty at M.I.T. are too numerous to list here. In the past year, five members of the faculty were elected to membership in the National Academy of Science; three members were elected to the National Academy of Engineering; and six were elected to membership in the American Academy of Arts and Sciences. Of special note during the year was the appointment of Gordon S. Brown, Dugald Caleb Jackson Professor of Electrical Engineering, to the distinguished rank of Institute Professor. Also of special note was the first presentation of the James R. Killian, Jr., Faculty Achievement Award to Professor Nevin S. Scrimshaw of the Department of Nutrition and Food Science.

The past year saw several appointments to senior posts that should receive special mention. Dr. Harold J. Hanham, an eminent historian, was appointed Dean of the School of Humanities and Social Science, beginning in April of 1973. Three new department heads were appointed during the year. They include Professor James W. Harris, Department of Foreign Literatures and Linguistics; Professor Walter S. Owen, formerly of Northwestern University, Department of Metallurgy and Materials Science; and Professor Herman Feshbach, Department of Physics. Professor John L. Buttrick was appointed Director of Music in the Department of Humanities.

In addition, several laboratories and centers at the Institute came under new leadership during 1972–73. The newly founded Energy Laboratory is headed by Professor David C. White of the Department of Electrical Engineering; Professor Salvador E. Luria of the Department of Biology was named Director of the Center for Cancer Research, also established this past year. Professor Peter T. Demos of the Department of Physics assumed the directorship of the Bates Linear Accelerator, and Professor Martin Deutsch of Physics was named Director of the Laboratory for Nuclear Science.

Of special note are three appointments of members of our faculty to distinguished posts in other institutions. Robert S. Freeman, Professor of Music in the Department of Humanities, was appointed Director of the Eastman School of Music in Rochester, New York; Henry A. Millon, Professor of the History of Architecture, during his sabbatical is serving as Director of the American Academy in Rome; and Emily L. Wick, Professor of Food Chemistry and former Associate Dean for Student Affairs, became Dean of the Faculty at Mt. Holyoke College. These appointments represent a special recognition of the high quality work of our three colleagues, and we wish them continuing success in their new duties.

Several new appointments to senior administrative positions also should receive special mention. General James B. Lampert, recently retired from a distinguished career in the United States Army, was named Vice President for Resource Development. Mr. Joseph J. Snyder, who has served the Institute for 22 years as Vice President and Treasurer, was named Treasurer of the Corporation and, in the resulting reorganization of the Institute's financial administration, Paul V. Cusick was named Vice President for Fiscal Relations, and Stuart H. Cowen became Vice President for Financial Operations. Natalie N. Nicholson, former Associate Director of the M.I.T. Libraries, succeeded Professor William N. Locke, as Director of the Libraries. Peter H. Richardson, former Associate Director of Admissions, became the new Director of Admissions, upon the retirement of Professor Roland B. Greeley, who served in the post for eleven years.

The past year also marked the retirement of eighteen members of the faculty. Their long and dedicated service to M.I.T. will be remembered by their students and colleagues alike.

Of particular sadness to us during the year were the untimely deaths of two of our most honored friends and colleagues. Donald G. Marquis, Professor of Organizational Psychology and Management, died suddenly in February, 1973. At the time of his death, he held the David Sarnoff Chair of Management of Technology, an esteemed professorship of which he was the first recipient.

Edwin R. Gilliland, Warren K. Lewis Professor of Chemical Engineering, died in the spring of 1973. Professor Gilliland served M.I.T. in the Department of Chemical Engineering for nearly 40 years and his professional work had earned him a national reputation. His career at M.I.T. was marked by outstanding services as a Department Head, Chairman of the Faculty, Deputy Dean of Engineering, and by other numerous awards and honors, notably appointment in 1971 to Institute Professor.

These men have been outstanding examples of strength and dedication to our educational programs; they will be long remembered and honored by generations of their students, friends, and associates.

In these days when science and technology are much blamed for the troubles in which we find ourselves, the task of maintaining and enhancing a prestigious institution dedicated to education in those fields seems a quixotic one to many. We regard it an important part of our role to try to understand, explain, and perhaps defend the role of technology. In our view the general disenchantment with science and technology would be more appropriately directed toward our society's decision-making processes for their slowness in recognizing the need for appropriate new technologies, than to science or technology itself. For example, we seem to be totally besieged by the many technology related problems, energy, transportation, pollution, etc. which seemed to descend on us simultaneously. However, this should not be so astonishing because we began to apply technology in a systematic and meaningful way not so many decades ago. The successful application of almost all of our technologies has followed an exponential growth curve; their effects are seemingly invisible one day and overwhelming the next. But that the growth curve was an exponential one has been known for many years. Foresighted people—Lewis Mumford, for example—had seen the potential problems of the cities, of pollution, of transportation failure, of overcrowding, etc. Some of us had anticipated the consequences of an open-ended arms race and recognized the obvious fact that we could not long afford a military budget which doubled every five years while the GNP doubled only every fourteen. The error signals were there, so to speak, but a decentralized democratic society like our own responds only when those signals get very large, big enough to be discerned clearly through the noise created by a constant competition for governmental attention and resources from many quarters.

We who are in the business of educating should see the whole society, as well as the Institute, as essentially a learning system. Each of us individually, and collectively through our various roles in private organizations and in government, is trying to learn how to make life just a little bit better. That is what society and government should be all about. In most learning processes, although we may not like to admit it, progress is made by trial and error. That is why we have engineering laboratories and build pilot plants. There is no instructor with the correct answer, and often there is not even *any* obviously "correct" answer. We, therefore, proceed through an iterative process of successive approximations seeking those activities and programs which will make life better for all of us.

If, as we maintain, many of our current difficulties are the result of not responding to error signals that were present—of not perceiving their importance early enough—then the remedy is to come to grips with that problem rather than resenting our achievements in science and technology. Continuing to provide the best technological solutions possible for society's problems must remain a major goal, and M.I.T.'s contribution must be the best possible scientific and technical education. We must continue to provide our society with both the expertise to invent its technological future, including remedies where appropriate, and a cadre of professionals in relevant fields who have come to fully appreciate the fact that social progress, like that in the sciences, is inevitably the result of many experiments. To the extent that, in the education of its students, M.I.T. can help them couple a scientific or engineering set of mind, committed to solving problems, with compas-

sion and a sense of involvement in human affairs, our task is by no means quixotic.

The importance of these issues for the health of our nation only points up more vividly the fact that the student is the central focus of our entire effort. The young men and women on our campus represent an exceedingly capable, scarce, and precious national resource, and they are a principal source of the continuing greatness of M.I.T. Their desire to come here is perhaps the best measure of the effectiveness of our educational program. It is in response to their changing needs and desires that we have developed collaborative approaches to teaching, research apprenticeships, and stylistically diverse alternatives to regular subjects and courses of study. The students, through their career interests, through the attractive force they exert on the faculty, and through the new ideas and capabilities they bring, are *the* critical variable in the future of the Institute.

A major item on our agenda for the coming years is to preserve our attractiveness to the ablest students. This challenge is twofold: to continue the development and evolution of superior educational programs and facilities; and to help students offset the costs of attending M.I.T. through scholarship, loan, fellowship, and assistantship programs. The role of costs in a student's decision to matriculate at a selective, private—and thus expensive—university is not entirely clear. It is clear that we cannot assume that all of the ablest students would be willing or able to meet our costs. The importance of student aid in shaping our future leads us to continue to assign top priority to this need as a fund-raising objective.

No single task is more crucial to our future than the preservation in generations to come, of a first-rate student body with whom we can participate in the intensely human and personal process, not of teaching them our knowledge, but of helping them to explore the thresholds of their own minds, to develop their full intellectual power, and to become strong, independent, self-reliant adults. In a world as dependent on science and technology as ours, in a world of growing complexity, in a world with increasing power, it remains true that, in the end, the shape of the future still ultimately must depend on the achievements of individuals.

Jerome B. Wiesner, *President*
Paul E. Gray, *Chancellor*

October 5, 1973

STATISTICS FOR THE YEAR

The following paragraphs report briefly on the various aspects of the Institute's activities and operations during 1972–73.

REGISTRATION

In 1972–73 student enrollment was 7,850, an increase of 133 over the 7,717 enrolled in 1971–72. This total was comprised of 4,183 undergraduate and 3,667 graduate students.

Graduate students who entered M.I.T. last year held degrees from 344 colleges and universities, 203 American and 141 foreign. The foreign student population was 1,405, representing 18 percent of the total enrolled. The foreign students were citizens of 97 different countries.

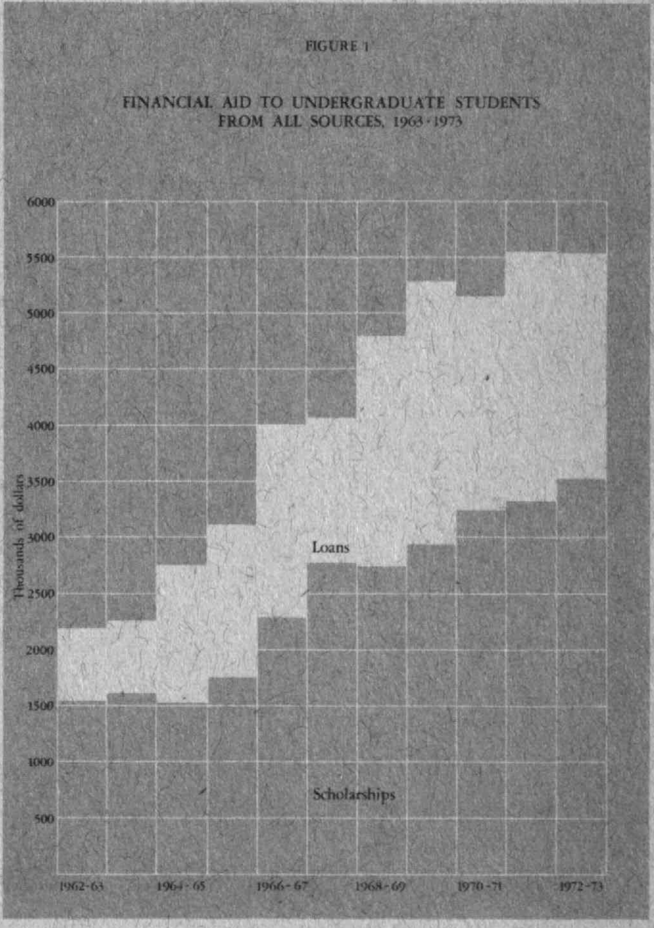
Degrees awarded by the Institute in 1972–73 included 1,038 Bachelor's degrees, 820 Master's degrees, 125 Engineer's degrees, and 396 Doctoral degrees—a total of 2,379.

The number of women at M.I.T., both graduate and undergraduate, has increased continuously. In 1972–73, 816 women students were at the Institute, compared with 698 in 1971–72. In September, 1972, 118 first-year women entered M.I.T. In 1972–73, 134 degrees were awarded to women.

STUDENT FINANCIAL AID

During 1972–73 the student financial aid program was again characterized by increases in total awards, in loans made, and in the amount of scholarship assistance. There was again a decrease in the number of individuals assisted.

A total of 1,973 undergraduates who demonstrated the need



for assistance (48 percent of the enrollment) received $2,962,081 in scholarship aid and $1,876,211 in loans. The total $4,838,292 represented a substantial increase in direct aid over last year.

Scholarship assistance was provided by the scholarship endowment in the amount of $1,967,801, by outside gifts for scholarships in the amount of $398,890, and by direct grants to needy students totaling $516,940. Scholarship assistance from M.I.T.'s own operating funds was not used during the year. The special program of scholarship aid to minority group students represented an additional $78,450 from specially designated funds. An additional 350 students received direct grants from outside agencies, irrespective of need, in the amount of $567,367. Outside scholarship support thus totaled $1,483,197, a decrease from last year's total. The undergraduate scholarship endowment was aided by the addition of new funds which represented an increase of $772,658 and which raised the principal of the endowment to $20,574,245.

Loans totaling $1,876,211 were made to needy undergraduates. Of this amount $433,966 came from the Technology Loan Fund, $1,442,245 from the National Defense Loan Fund, and the remainder from other M.I.T. loan funds. An additional $433,921 was obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained $751,355 from the Technology Loan Fund. Of this total, $299,690 was loaned under the Guaranteed Loan Program and qualified for Federal interest subsidies and guarantees. The total loaned by M.I.T. to 2,267 graduate and undergraduate students was $2,633,216, an increase of $169,852 over last year's total.

CAREER PLANNING AND PLACEMENT

During 1972–73, job opportunities for new graduates increased markedly after two relatively lean years. Prospects were especially bright for graduates in engineering, whether at the Bachelor's, Master's or Doctoral level. There was a 15 percent increase in companies and government agencies recruiting at the Institute; starting salaries rose an average of 5 percent after holding at a stable level for three years.

The improved economic climate was also visible in alumni placement. The number of alumni registering with the Office dropped to about 420 from 710 who registered last year and 972 who registered the year before, a sign that alumni were less worried about their jobs or their chances in the job market.

Students consulted the Career Planning and Placement Office throughout the year for advice on options available to them in their particular fields of interest. Those seeking advice ranged from freshmen selecting majors to doctoral and postdoctoral candidates newly in the job market. The Office was especially busy this year working with women and minority students.

FINANCES

As reported by the Treasurer, the total financial operations of the Institute, including sponsored research, increased beyond

FIGURE 2
FINANCIAL AID TO GRADUATE STUDENTS
AWARDED BY M.I.T. 1963-1973

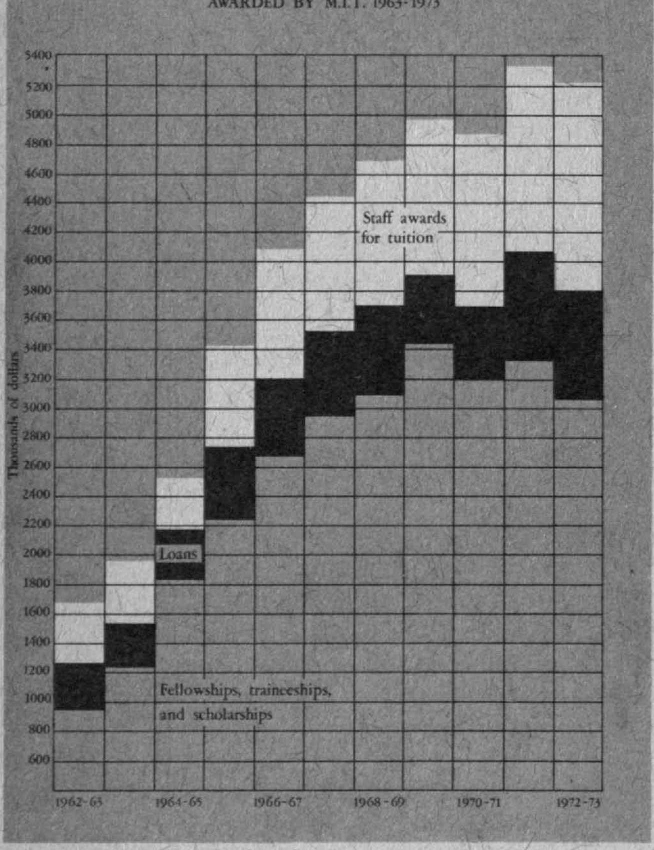
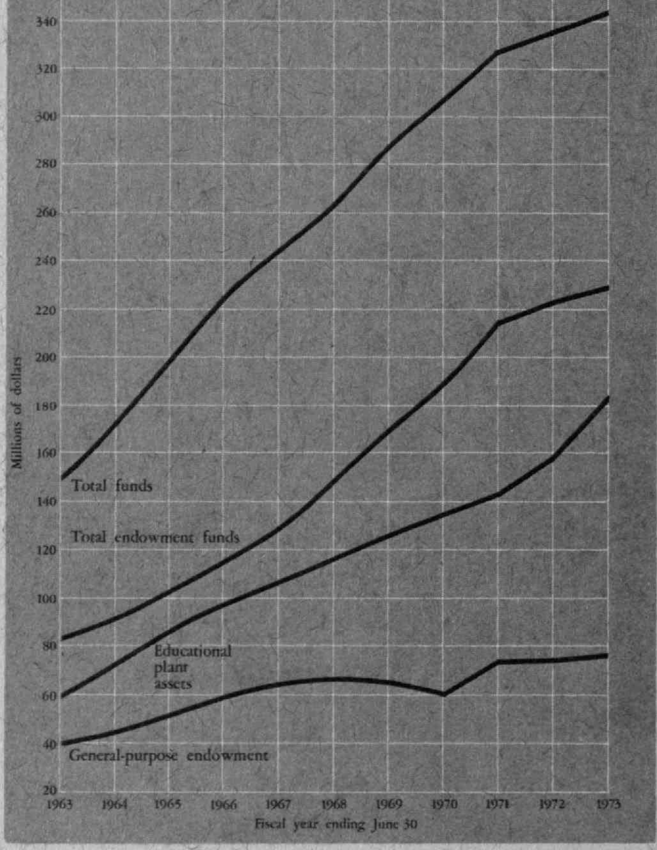


FIGURE 3
THE GROWTH OF M.I.T.'S FUNDS AND PLANT ASSETS, 1963-1973



the level of 1971–72. Educational and general expenses—excluding the direct expenses of departmental and interdepartmental research, the Lincoln Laboratory, and the Charles Stark Draper Laboratory—amounted to $75,297,000 during 1972–73, compared to $72,512,000 in 1971–72. Reflected in the finances of the Institute was the decrease in the use in operations of unrestricted funds to $757,000, compared with $1,593,000 in the preceding year.

The direct expenses of general departmental and interdepartmental sponsored research increased from $56,467,000 to $58,704,000, and the direct expenses of major laboratories and special departmental research increased from $101,143,000 to $129,613,000.

The construction program of the Institute continued to make progress in 1972–73, with the book value of educational plant facilities increasing from $157,651,000 to $182,063,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, had a book value of $339,333,000 and a market value of $440,924,000. This compares to book and market totals of $332,752,000 and $445,866,000 last year.

GIFTS

Gifts, grants, and bequests to M.I.T. from private donors decreased from $22,049,000 for fiscal year 1971–72, to $21,664,000 for fiscal year 1972–73. The latter figure includes unrestricted direct gifts to the Alumni Fund of $833,000, which made up a part of the total of $3,184,000 reported by the Alumni Fund in 1972–73.

PHYSICAL PLANT AND CAMPUS ENVIRONMENT

In the fall of 1972, the Tang Residence Hall, located on the west end of the campus, was completed and occupied by 401 graduate students. Tang Hall was dedicated, following the 1973 Commencement exercises, to the memory of Mr. P. Y. Tang, an M.I.T. alumnus of the Class of 1923.

Also completed during the year was the electrical engineering and communications research facility, the largest single building project at M.I.T. since the present campus was built in 1916. This facility, named the Sherman Fairchild Electrical Engineering and Electronics Complex, will be dedicated in October, 1973. It will be occupied by the Department of Electrical Engineering and the Research Laboratory of Electronics.

Major construction was initiated during the year on two other academic and research projects—the Chemical Engineering Building, an architecturally reinforced concrete structure of five floors located to the east of the Whitaker Building, and the Seeley G. Mudd Building adjacent to the Ford Building. The latter involves complete renovation of a former Institute investment property to accommodate health related research, including a cancer research facility, a cellular tissue laboratory, and an addition to the M.I.T. Clinical Research Center.

In the area of housing, major renovation of Ashdown House was begun in February, 1973, with completion scheduled in two phases—fall, 1973, and summer, 1974. Planning

The Sherman Fairchild Electrical Engineering and Electronics Complex, the largest single building project at M.I.T. since the present campus was built in 1916, was completed during the year and is occupied by the Department of Electrical Engineering and Research Laboratory of Electronics.

studies are underway for additional student housing for the West Campus.

Baker House was closed during the summer for the first time since it was first opened in 1948. During the closing, a number of projects were completed in the building, including the replacement of all windows on the side of the building facing Memorial Drive.

Throughout the year, the Committee on Research and Space Planning, under the chairmanship of the Provost, carried out the responsibility of assessing departmental requests for space—judging priorities and determining actual space allocations. The area vacated as a result of the completion of the Fairchild Complex and the movement of central telephone operations from the Maclaurin Building to the Ford Building was the most significant block of space to become available at the Institute in a number of years; extensive efforts by the Committee on Research and Space Planning have been undertaken to optimize the use of this space to relieve crowding in growing activities, to provide more coherent space for scattered activities, and to facilitate the shifts in new directions of research and teaching.

Howard W. Johnson, Chairman of the M.I.T. Corporation, Jerome B. Wiesner, and Mrs. P. Y. Tang attend the dedication of Tang Hall, a 24-story graduate student residence named in honor of Mr. Ping Yuan Tang, an M.I.T. alumnus of the Class of 1923.

Institute Review

"A Moderate Gain in Financial Strength," but a Guarded Prognosis from the Treasurer

"The productive allocation of resources to achieve the basic objectives of the Institute within the constraints of continued financial integrity . . ."

In those words from his 1973 annual report are wrapped up Joseph J. Snyder's problem—the agenda that makes his job as Treasurer of the Institute both hard and interesting.

How did it go in 1972-73?

Well enough, thinks Mr. Snyder, considering what college and university treasurers are up against these days. There was "continued improvement in the finances of M.I.T." during the year, he told the Corporation on October 5, and the Institute "gained moderately in financial strength."

But long-term stability appears elusive. "Further growth in the endowment and other funds, major additions to educational plant, financing of a substantial program of student aid in the face of declining federal support of graduate fellowships, and reduction in the use of unrestricted resources to fund operations are clear evidence of a year of satisfactory fiscal results," he said.

Among the highlights of Mr. Snyder's report: ". . . tuition revenues and investment income increasing, departmental research activities well maintained, further special and successful steps to control costs reflected in operations, the provision of new resources through the continued strong support of alumni and friends . . ."

Keeping Unrestricted Resources Unrestricted

The heart of the issue comes in Mr. Snyder's discussion of the Institute's unrestricted resources—the gifts, investment and patent income, and other funds whose use is discretionary. In the best of times such funds can be devoted entirely to long-range purposes—buildings, endowment, special projects. In more difficult times, including some recent years, they have been absorbed largely by current, day-to-day expenses.

Unrestricted resources of $3.775 million were available in 1972-73. Some $2.674 million was allocated for operations, for student aid, and for other purposes, and of this only $757,000 is classified as current operating expenses; on July 1, 1973, $1.101 million remained to be allocated.

During the year $1.5 million—the last of the unrestricted funds remaining from 1971-72—was set aside as endowment for professorships.

In the 12-year period starting in 1961-62, Mr. Snyder tcld the Corporation, 44 per cent of all unrestricted resources had been allocated to endowment, 26 per cent to building construction, and 8 per cent to miscellaneous purposes; only 22 per cent had been devoted to current operations. In all, over $36 million of unrestricted resources has been added to endowment since 1961, he said.

There has been no invasion for current expenses of endowment funds or of capital gains on them; indeed, during the last 10 years the annual net increase in M.I.T.'s total funds has ranged from $7.071 million in 1972 to $38.397 million in 1966; in 10 years from 1964 to 1973 the funds have more than doubled, growing from $150 to $342 million.

"Productive" Resource Management

But the building of the funds is only part of the Treasurer's job, says Mr. Snyder; there is also "the productive allocation and spending of the revenues and funds to provide the best results in instruction and research."

On that score, Mr. Snyder's 1972-73 report is very positive:

—The value of the educational plant increased from $157.6 to $182 million, most of the growth representing the Sherman Fairchild Building, the Tang Residence Hall, and early construction on new laboratories for cancer research and chemical engineering.

—Total operations for 1972-73 were $269.6 million, up from $235.5 million in 1971-72—an increase "due largely to increased expenses in the special laboratories," Mr. Snyder said.

—Gifts for endowment in 1972-73 were $2.127 million, in large part capital funds for professorships and scholarships. In 1971-72 the figure was $2.68 million.

—Gifts for buildings were $5.45 million, up from $2.4 million the previous year.

—Expenses for teaching and unsponsored research were $29.5 million in 1972-73, up from $27 million in 1971-72. The direct cost of departmental and interdepartmental research (not including the Draper and Lincoln Laboratories) was $58.7 million, up from $56.6 million.

—Over $2.3 million of endowment income was used for scholarships and fellowships in 1972-73, up from $1.7 million.

Despite his cautiously favorable 1972-73 report, Mr. Snyder's conclusion is a warning: the favorable trends of the current year "can be sustained only by the continued careful management of costs, the prudent allocation of existing resources, the productive investment management of endowment, and the further strong development of new resources for the future well-being of M.I.T.

"The growth in the funds of the Institute during the last 10 years has worked to strengthen M.I.T.," Mr. Snyder wrote, "but this growth must be sustained and possibly increased during the next five to 10 years if the Institute is to stabilize its finances and achieve its basic goals in education and research."

A New Round of Pressure on Budgets, and a Longer Shadow Still Ahead

If there was, in the Treasurer's words *(see above)*, "continued improvement in the finances of M.I.T." in 1972-73, what of the future?

The answer to that question has two parts, describing a short-term, nonrecurring problem in 1973-74 and a long-term imbalance for which budget-cutting exercises provide no solution. To the second, transcendent problem Paul E. Gray, '54, Chancellor, sees two possible and necessary responses:

—Increase the productivity of educational programs.

—Find an entirely new level of support through gifts and grants for endowment and program funding.

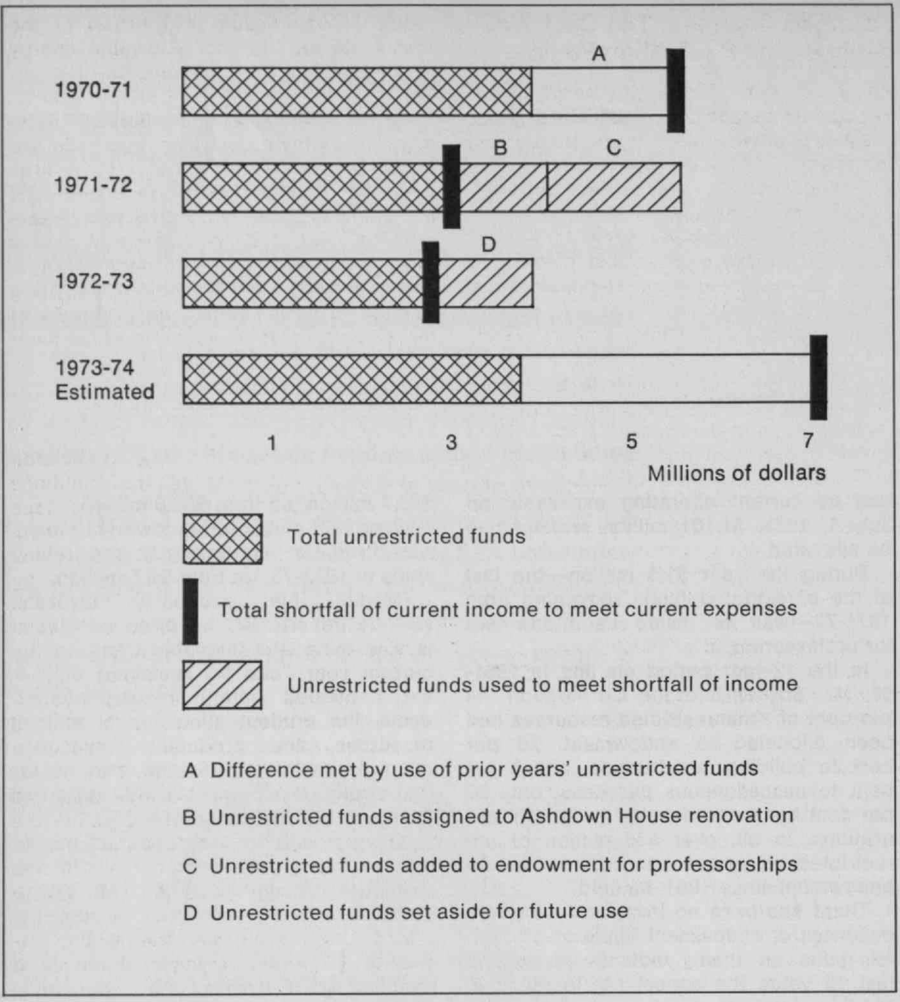
Thus, said Dr. Gray in a crisp, stern report to the faculty on October 17, the future holds:

—"Substantial reductions" in the educational and general operating budgets for 1974-75.

—Fuller use of "the human, intellectual, and physical resources of the Institute . . . in teaching larger numbers of students who may represent entirely new constituencies" in the longer-range future.

Trying to Cut Another $1.5 Million

The Institute's projections for 1973-74 show that income other than unrestricted



In two of the past three years, unrestricted income received during the year has been more than enough to make up the difference between M.I.T.'s expenses and its income; in 1971-72 $2.5 million of unrestricted funds were available for special non-operating purposes, and $1.1 million of such funds were set aside for future use in 1972-73. But the shortfall of income under expenses, according to present estimates, will rise to $7.1 million in 1973-74 because of sharp inflation and divestment of the Draper Laboratory.

funds will fall short of expenses by $7.1 million—the largest such figure in M.I.T. history, about $4.4 million more than the similar figure for 1972-73. Against this need there will be unrestricted income of about $3.8 million in 1973-74 and $1.1 million of unrestricted income carried forward from 1972-73. Reserve funds of $2.2 million will be needed.

But $2.4 million of the $7.1 million shortfall is a nonrecurring gap between income and expenses due to divestment of the Charles Stark Draper Laboratory on July 1, 1973 (*see October/November, pp. 83-84*), and so Dr. Gray regards "the use of reserves up to this level of expense . . . appropriate if regrettable."

The $7.1 million shortfall now in 1973-74 budgets has two principal sources:
—Inflation in the cost of M.I.T. purchases, particularly of energy, "beyond the estimates made as recently as last spring." Frozen overhead rates mean that all of these unexpected increases fall on the educational and general operating budget.
—The divestment of the Draper Laboratory, under the terms of which overhead rates throughout the Institute were frozen at a level which has turned out to be substantially less than the true rates. There is a recurring loss of $1 million due to the reduced volume of sponsored research on which overhead is calculated and a nonrecurring loss of $2.4 million due to underrecovery in 1973-74 only.

All this means that the problem of budgeting for 1974-75—a process now underway throughout the Institute—will be tough indeed. Though he gave the faculty no targets, Dr. Gray suggested that a gross reduction in expenses of $1.5 million in 1974-75 would leave a deficit of about $1 million, if unrestricted income continues at recent levels. Reductions achieved for 1972-73 and 1973-74 were $3.4 million and $2 million, respectively.

If—in the light of those figures—$1.5 million seems an easy target, look again. "Budget trimming will be increasingly difficult," thinks Dr. Gray. "Most of the obvious savings have been taken, and further cuts will come much closer to the bone." And because the largest budget cuts in the past two years have been in administration and plant expenses, "the emphasis in the next year or two must shift toward academic budgets."

A $1 Million Annual Problem

Beyond these demands, "to which we can and will respond by reducing costs as necessary," Dr. Gray said, lies a long-range problem which is far more serious. It is that every year, even without additions to program, M.I.T.'s expenses rise faster than its income. The difference is about $1 million each year, and Dr. Gray admitted that it "casts a long shadow on our planning."

The principal source of this continuing problem is salaries and wages. If M.I.T. is to maintain the excellence of its faculty and staff, "its salaries must rise at rates at least comparable to the rate of growth of personal or per capita income in the U.S.," thinks Dr. Gray. And that rate is higher than any rate of inflation which may govern increases on the income side of M.I.T.'s ledger.

"We seem to have reached a plateau with respect to gifts and grants," said Dr. Gray. Tuition should, he thinks, rise no faster than the general rate of inflation. The securities market, and federal limits on dividend growth, suggest that a rate of endowment growth of 6 per cent a year over the next few years "would be extraordinarily good." And increases in research at M.I.T.—though some are expected in the next five years—will hardly reduce by $1 million or more a year the share of indirect costs which fall to the teaching and unsponsored research programs.

Two alternatives remain, said Dr. Gray, since budget-cutting exercises provide no long-term solution to such a chronic problem: increase gifts and grants and the amount of (and therefore the income from) endowment; and increase productivity.

Productivity: Changing Our Life Style?

As Dr. Gray admitted, productivity is a hard subject to talk about with university professors; the educational process "properly focuses so centrally on the individual, . . . and efforts to increase educational productivity will necessitate careful examination of most aspects of our institutional life style." There may be changes in "traditions, habits, and modes of operation that are of long standing."

But if "the only alternative is one of continued annual budget trimming on a large scale, with all its corrosive qualities," thinks Dr. Gray, "the choice is clear."

Pressed by the faculty for further comments on productivity, Dr. Gray said it "simply means using our capabilities to a greater extent." He cited "many classes which are very small," and suggested the possibility of year-round utilization of the academic plant.

Tuition Up 8%, and Protesters Are Threatened with a Freeze

Annual tuition increases have become routine in recent M.I.T. history, and everyone expected an announcement for 1974-75 during the summer.

It came, instead, in mid-October, and it brought bad news: instead of the 6 per cent increases of the early 1970s,

tuition in 1974-75 would be up 8 per cent, to $3,350, from this year's $3,100.

Despite recent efforts throughout M.I.T. to control expenses, said President Jerome B. Wiesner in an announcement to *The Tech,* "inflation continues to drive up our costs." Utilities are an example—and, according to Paul E. Gray, '54, Chancellor, the decisive one in determining that the 1974-75 tuition increase would be two percentage points more than previous recent hikes. The Institute's lighting and heating bills for 1973-74 will be up at least 25 per cent—an additional cost of some $800,000 during the year.

"Tuition income is one of the principal sources of the Institute's nonresearch operating revenues," President Wiesner wrote, "and must continue to bear its proportionate share of our costs." He pledged major efforts to develop new resources for endowment and income from it, but in the meantime the Executive Committee of the Corporation and the M.I.T. administration have found "no responsible alternative" to higher tuition.

Speaking to the faculty, Paul E. Gray, '54, Chancellor, said it should be the Institute's endeavor to keep the rate of tuition increase to 5 or 6 per cent a year, at or slightly below the rate of increase of U.S. median family income. The increase at the 8 per cent rate for 1974-75 "is larger than either our policy objective or what can be sustained over several years," Dr. Gray said. "We hope and expect that this larger-than-normal increase will not be repeated."

Though President Wiesner said that the decision for 1974-75 was reached "with great reluctance, knowing the added burden it puts on the resources of our students and their families," student reaction to the announced tuition increase was mild—almost *pro forma.* The "annual, spontaneous tuition riot" was announced by *The Tech* for October 17, more than 24 hours after the tuition increase was announced in its pages—the date reportedly set so that President Wiesner and Vice President Constantine B. Simonides would both be in town.

The protesters followed the "traditional plan," said *The Tech* in describing the evening: "marching on the [empty] office of President Wiesner, blocking traffic at 77 Massachusetts Avenue, 'storming' McCormick Hall, and then moving down to the [empty] President's House." There Mr. Simonides "was reported to have been overheard saying, 'Where's Jerry?' when surrounded by a group of students. Dr. Wiesner did not appear. . . . A bottle of water from the Charles River was poured on the door-step in a symbolic gesture."

The crowd, by then down to 150 of the original 300 "rioters," moved on to the Green Building, where 20 gained entrance, went to the roof, and "threw down paper airplanes, toilet paper, and firecrackers. After about 20 minutes they were persuaded to leave by Mr. Simonides, who is reported to have told them, 'Anyone here overnight will freeze to death.' "

Fairchild Complex: The Cast Was Brilliant, the Dedication Pallid

Some of the offices are windowless. Though its facade is unblemished glass, there are pillars of concrete throughout the interior. Moisture condenses on the air conditioning ducts above the false ceiling, then drips down to discolor it.

But the buildings are home to several hundred engineers in shirt-sleeves who, often as not, eat their lunches from vending machines. It is the largest and most expensive building project since M.I.T. moved from Boston to Cambridge in 1916, and on October 5 it was dedicated: the Sherman Fairchild Electrical Engineering and Electronics Complex.

The Corporation and administration of M.I.T., the Department of Electrical Engineering, and the Research Laboratory of Electronics went through all the proper—and some rather extraordinary—motions to mark the event. But most of the rest of the community went undisturbed about its daily business, "just sort of glancing in at all the people and wondering what was going on," as one observer told *The Tech.*

All six of 'the most influential men of science"—*The Tech's* phrase for the former White House science advisers—appeared together on the Kresge Auditorium stage on Thursday evening, October 4; their collective experience in science and public policy could hardly be matched again—especially considering that H. Guyford Stever, Director of the National Science Foundation, and Pierre R. Agrain, who holds the equivalent of the science adviser's post in the French government, were in the audience (*see pp. 63-64*). But the hall was far from full.

Science: Still an "Endless Frontier"

Dedication events resumed on Friday, October 5, when the Corporation adjourned its annual meeting and Dr. Stever in his luncheon address affirmed that science is "still the endless frontier," just as it was when Vannevar Bush, '16, coined that phrase at the end of World War II.

When R. L. E.—a principal inhabitant of the new Fairchild Building and M.I.T.'s pioneer interdepartmental laboratory whose success in that role is still unequalled—was founded, Dr. Stever noted, science was riding the crest of a wave, having proved itself "a new element necessary for military success." Today the emphasis is very different, and Dr. Stever thinks the "strong upswing of support for science in its civil role is only beginning."

Yet he admitted, too, that "the power of science is no longer taken on faith. The type of problems set before us by (an increasingly skeptical society) are not the kind that will be solved by a few singular breakthroughs. Most are systems problems that call for strategic combinations of scientific, technological, social, and political advances," thinks Dr. Stever, and he guessed that "no one of us here today underestimates the scope and difficulty of those problems."

Energy, for example: "The work involved in making an orderly transition from a fossil fuel age to an energy era based on the fission and fusion of the atomic nucleus or the renewable energy of the sun has truly monumental implications."

But in science, said Dr. Stever, "as in many other things, nothing succeeds like success. . . . We must rally to the idea that the frontiers of science are still endless." And we must give new meaning, he said, "to the words Vannevar Bush wrote almost three decades ago: 'On the wisdom with which we bring science to bear against the problems of the coming years depends in large measure our future as a nation.' "

"The Most Perfect and Practical Laboratories"

From the luncheon, a few dedication guests ventured forth to the buildings themselves, where they found ambitious displays of communications science, cookies and punch, and a string orchestra composed of electrical engineering graduate students playing in the halls. The displays turned out to be of special service to a few students surveying the field for courses and thesis topics.

The official dedication was accomplished in mid-afternoon on October 5 by Walter Burke, President of the Fairchild Foundation, whose $4 million was the largest of at least 260 individual and corporate gifts which made possible the building. In addition, there were facilities grants of $1.8 million from the National Institutes of Health and the U.S. Office of Education.

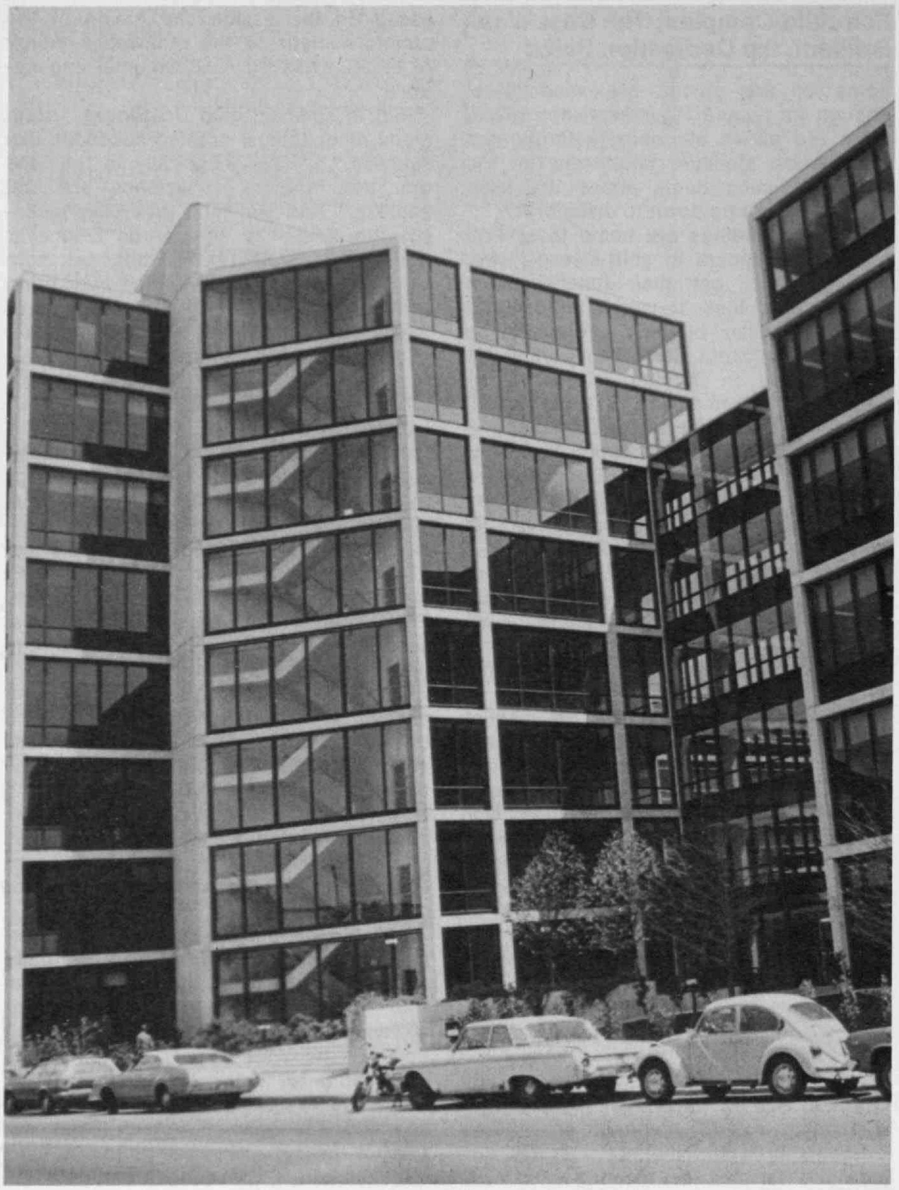
Mr. Burke described the late Sherman M. Fairchild, founder of Fairchild Camera and Instrument Corp., as a man with three "abiding interests"—photography, sound reproduction, and aircraft design; "he was equally at home with magnetic tapes and flying boxcars."

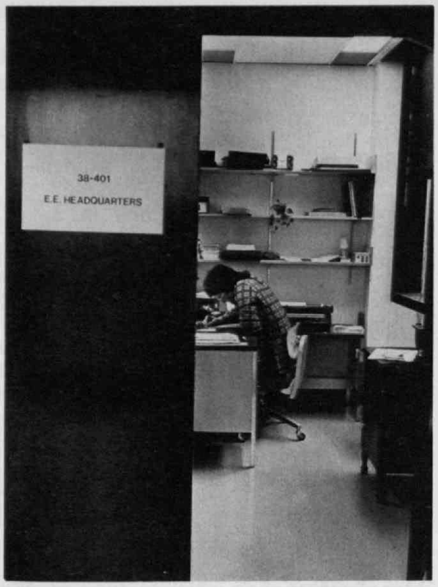
President Jerome B. Wiesner responded: Sherman Fairchild "was our kind of inventor, depending upon a thorough technical knowledge to create sophisticated apparatus . . . a perfectionist in everything that he did. . . . He would have fit into the Electrical Engineering Department and R.L.E. very well indeed."

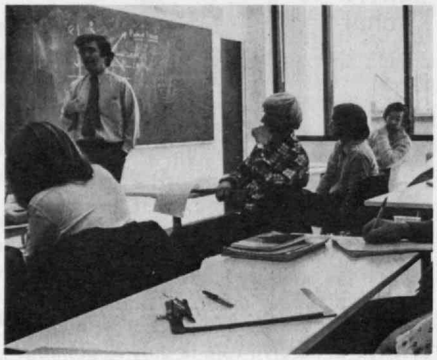
In the formal address of the dedication, President Emeritus Julius A. Stratton, '23, who was R.L.E.'s first Director, recollected an earlier ceremony when President Henry S. Pritchett declared that $270,000 spent in 1901 had just yielded for M.I.T. "one of the most perfect and at the same time one of the most practical electrical laboratories in the world."

Today's teaching is different: "the domain of electrical engineering is one of the most awesome dimensions—reaching out into countless new fields, penetrating into a multitude of once-isolated disciplines," said Dr. Stratton. But the elements of effective teaching and research which made electrical engineering great in the past will be secure in the future, and "I have utter confidence that wonderful opportunities lie ahead."

If the audiences lacked size and the ceremonies a touch of brilliant color, *The Tech* had a too-easy explanation: "It is difficult to comprehend how M.I.T.'s largest department, considered one of the best in the area of promotion and student involvement, could proceed with







The exterior and interior of the Sherman Fairchild Electrical Engineering and Electronics Complex hardly distinguish it from other new M.I.T. buildings. But its purposes set this building apart, thinks Julius A. Stratton, '23: "The domain of electrical engineering," he said at dedication ceremonies in October, "is one of most awesome dimensions . . . penetrating a multitude of once-isolated disciplines." At the dedication luncheon (center, below), H. Guyford Stever, Director of the National Science Foundation, put the new facilities in the context of Vannevar Bush's ('16) view of the endless frontiers of science, and later President Jerome B. Wiesner (left, photo below) and Howard W. Johnson, Chairman of the Corporation, posed with members of the Fairchild Foundation in the lobby of the new building. (Photos: Sheldon Lowenthal, '74, Margo Foote, and Roger N. Goldstein, '74)

plans for the dedication of its new complex without allowing students to play an active role."

Nor is it fair to think that the climate on the M.I.T. campus has so changed in two years that presidential science advisers and science policymaking must be almost totally ignored; the few students who came on Thursday evening had questions which Norman D. Sandler, '74, of *The Tech* correctly described as "self-serving."

The Tech in the White House: When Nixon Gave Edgerton the National Medal of Science

When the White House announced that Harold E. Edgerton, Sc.D.'31, Institute Professor Emeritus, would receive the National Medal of Science on October 10, The Tech *resolved to cover the ceremony. Here is his account of the adventure by Norman D. Sandler, '75, Executive Editor.*

The National Science Foundation, which took charge of the Medal of Science awards when the Office of Science and Technology was disbanded by the President last January, said it would be impossible to accredit two college students for the ceremonies at which the 1973 Medals would be awarded. Time and security, they said; one N.S.F. official assured me that he couldn't get even his brother into the White House that night if he wanted.

But one of the 11 medalists was "Doc" Edgerton, and *The Tech* wanted to be there. So a short time later we were on the telephone to the White House Press Secretary's office, requesting accreditation. We persisted, and three hours later a member of the staff called back to confirm the arrangements: we were cleared for the presentation, she said.

I went to Washington with David M. Breuer, '74, as photographer. Dave has been a teaching assistant in Professor Edgerton's strobe course, one of the most popular laboratory courses at M.I.T., and he credits "Doc" with seriously introducing him to photography.

Standing at the White House gate on October 10 we fell temporary victims to the federal bureaucracy. The White House guards said the press office had no record of us or of *The Tech*. I placed a quick call to the Assistant Press Secretary, and when we returned to the gate the guard said that someone in the press office had found our clearances shortly after we had been told they were nonexistent.

"All the Brains Don't Happen to Be in New England"

So for the first time in my short journalistic career I found myself in the White House, flanked by correspondents for the major networks, newspapers, and magazines. Members of the Nixon cabinet, families and friends of the Medal recipients, and other dignitaries were all assembled for one of Nixon's infrequent semi-public appearances.

The band struck up "Hail to the Chief," in came President and Mrs. Nixon, and the President opened the ceremonies with a comment about all areas of the country being represented by the winners: "All of the brains don't happen to be in New England, or for that matter in California. Because, as you will find out, there are award winners from California, from Texas, from Florida, from Illinois, and, of course, from M.I.T. in New England."

President Nixon lauded the efforts of scientists in building up the nation's defense capabilites, but he challenged them now to redirect research and development efforts to civilian needs—especially energy. On the latter, he said he plans increased federal support of basic research to make the country self-sufficient for energy. But he did not outline any specific programs to attain this self-sufficiency, and the question still remained as to whether he would back up his statements and challenges with policy initiatives.

Mr. Nixon spoke confidently, especially for a man who knew—as we, of course, did not—that only two hours later his Vice President would announce his resignation under pressure of criminal charges.

After the ceremony the National Science Foundation held a reception at the State Department, after which we returned to the White House, where I was to pick up a copy of the President's remarks during the medal presentations.

There were several reporters at the White House gate when we arrived by cab at about 2:15. They weren't being allowed in because they lacked White House credentials. But the guard recognized me from earlier in the day and signaled me through. It was obvious that something was up, but the guard wouldn't tell me what. That became clear when I reached the Press Secretary's office.

Then I set out on the second big story of my six-hour career in the White House press corps.

Though his adventures in the name of engineering have carried him to every continent, height of land, and depth of ocean, Harold E. Edgerton, Sc.D.'31, obviously found the experience of receiving the National Medal of Science from the President of the U.S. a joyful one. (Photo: David M. Breuer, '74, from The Tech)

M.I.T. in an Era of "Anti-Technology"—We Fit the Problems Like a Glove

What role for M.I.T., in an era when science and engineering seem to be low—and perhaps slipping lower—among national priorities?

The question was posed by Howard W. Johnson, Chairman of the M.I.T. Corporation, as he opened the 1973 Alumni Officers' Conference for over 400 alumni leaders and their guests from throughout the U.S. on September 15.

Amplifying the question, Mr. Johnson cited the recent report of the National Science Board: a marked reduction in the proportion of the gross national product devoted to research in science and engineering in the U.S.—"a cause for concern," he said, "for country, for M.I.T., and for you as alumni."

Mr. Johnson's question found its answer as alumni heard, throughout the day, that few if any institutions in the U.S. are more pertinent than M.I.T. to the issues which are at the base of today's lowering confidence in technology.

The basic concept of M.I.T.'s founder, William Barton Rogers, emphasizing "the dignity of useful work," finds expression today in the Institute's strong coupling of science and engineering with social science—economics, political science, and international studies, said Paul E. Gray, Chancellor. A new example is a plan for a "trans-disciplinary" teaching program in the School of Engineering which will emphasize "the cognitive style of the engineer" instead of detailed knowledge of any single engineering discipline.

The current frustrations of society are not failures of technology—but of our understanding of its effects, said President Jerome B. Wiesner. Our need, he said, is to "consciously manage the power that technology makes available" so that we can "solve existing problems without creating new ones." It's the kind of understanding which is especially possible at M.I.T.—an institution devoted to both technology and a quantitative approach to the social sciences.

Referring to new plans for the School of Humanities and Social Studies, Harold J. Hanham, its new Dean, emphasized "how little progress has been made in understanding the relation of technological change to social change." And especially at M.I.T., he thinks it "incredible that we have not developed a study of the relationship of science and technology to society."

For example, said Dean Hanham, consider the telephone. Studying it as a technological development is not now

What can M.I.T. do about continuing education for its alumni? What about more emphasis on education and jobs for women and minorities? How can you make clearer the central role of science in modern society? Questions like these were brought from throughout the U.S. to the Alumni Officers Conference in September—so many that Walter A. Rosenblith, Provost, said he feared the result may have been a "dehydrated view" of M.I.T. Among the principals: President Jerome B. Wiesner, responding (above) at a discussion session; Mr. and Mrs. William S. Edgerly, '49 (he is President of the Alumni Association); and (right) Stanley M. Proctor, '43, A.O.C. Chairman, and Ellis C. Littman, '33, of the Alumni Board of Directors. (Photos: Sheldon Lowenthal, '74)

very fruitful. But its implications for changing social relationships and for the future course of technological development are little understood—and these, he said, are typical of a new teaching and research emphasis in the School.

Another interrelationship of technology and society cited by Louis Menand III, Assistant to the Provost: the impact of technology on the constitutional system—for example, on concepts of privacy. (The obvious reference to Watergate was not lost on the alumni audience.)

Interlocking technological and social issues are nowhere more important than in the "energy crisis," said Henry D. Jacoby, Professor of Management. The cost structure of energy is changing, because we now must consider not only the money cost but as well the environmental cost and the "dependence cost" (the cost of relying on foreign resources). Such public policy issues are interacting with engineering problems, and the result is "a new style" of issue with which we hardly know how to deal.

How can teachers respond to this new need for technology to be understood in its social context? Consider "Concourse," an experimental freshman-year program based on "collaborative" teaching by a group of faculty from science, engineering, and humanities. Students take courses from the regular M.I.T. curriculum and also participate in a series of "general meetings" designed to focus on "the technological side of society—its power but its incompleteness in relation to precious, humane aspects of life," said David A. Oliver, Assistant Professor of Aeronautics and Astronautics.

Though it is an institution based in technology, M.I.T. will resist "the trend toward quantification of the educational process," Dr. Gray pledged to his alumni audience at the Conference banquet. Education, he said, is "a process uniquely dependent on the elusive and fragile nature of personal relationships," and Dr. Gray believes that the Institute's future will depend on its ability to attract such good students that the faculty continues to be uniquely rewarded by personal contact with them.

Nearly every aspect of M.I.T.'s programs came under alumni scrutiny in question-and-answer discussion sessions—educational programs, admissions, financial management, affirmative action programs, recruiting of women and minority students, financial aid, and a host of others.

Among all these issues, three were least resolved as A.O.C. discussions continued:

—How is M.I.T. preparing to help alumni maintain their professional effectiveness in an era when the objectives of science and engineering are changing while the rate of technological change continues to accelerate?

—What about the involvement of alumni in Institute affairs? What sort of help—other than financial—does M.I.T. need, and by what mechanisms can it be given?

—And finally a question from Robert C. Cowen, '49, during one of the discussion sessions: If science and engineering are in fact lower among the nation's priorities because people fear that new tech-

Eight alumni discovered that there is more to a Bronze Beaver Award than a small bronze replica of the Institute's mascot during the Awards Luncheon of the Alumni Officers Conference in September; there is the pride of their fellow-alumni in their work and their Institute. Left to right: Gordon S. Brown, '31, Hugh W. Schwarz, S.M.'42, Glenn P. Strehle, '58, Susan E. Schur, '60, William C. Sessions, '26, James H. Eacker, '55, Paul L. Hotte, '42, and Hal L. Bemis, '35. William B. Bergen, '37, was unable to be present, and his Bronze Beaver was delivered at a meeting of the M.I.T. Club of Los Angeles in the fall. (Photo: Sheldon Lowenthal)

nology will bring only new problems, not new solutions, what is M.I.T. doing to change this erroneous view?

"We're doing what we can," said Albert G. Hill, Vice President for Research; "we're working hard. But we haven't laid a glove on the problem yet."

How to Make them Smile: Bronze Beavers and Presidential Citations

We hope they were as pleased as they looked: eight members of the M.I.T. community called to the platform to receive the highest award of the Alumni Association of the M.I.T.—a ninth award was designated but its recipient could not be present—at the Awards Luncheon of the 1973 Alumni Officers Conference.

There is, in other words, more to a Bronze Beaver than a small sculpture by the late Henry B. Kane, '24, and a (usually) flowery citation.

Four Presidential Citations also presented at the Luncheon by William S. Edgerly, '49, recorded their alma mater's debt to an unusually large number of alumni for their services to the Association in 1972-73.

The Bronze Beaver recipients:

—**Hal L. Bemis**, '35, for support of the Alumni Fund, the Educational Council, and the M.I.T. Club of Delaware Valley in the Philadelphia area.

—**William B. Bergen**, '37, whose alumni service from Los Angeles has ranged over the full scale from Corporation to local club and Alumni Fund prgrams

—**Gordon S. Brown**, '31, Institute Professor Emeritus throughout whose faculty service since 1931 has been the effort to strengthen the bonds between alumni and M.I.T.

—**James H. Eacker**, '55, the special champion of student housing and environment among alumni and potential supporters.

—**Paul L. Hotte**, '42, for an abundance of "commitment, dependability, enthusiasm, humility, and imagination" in alumni service.

—**Susan E. Schur**, '60 President of the Association of M.I.T. Alumnae, for her many efforts to stimulate the interest of alumnae in women's affairs at the Institute.

—**Hugh W. Schwarz**, S.M.'42, a leader and worker in local, regional, and national Association and M.I.T. activities.

—**William C. Sessions**, '26, for long-time service to his Class and to all M.I.T. activities in the Cleveland area.

—**Glenn P. Strehle**, '58, for active participation and leadership of the Alumni Fund and other Association boards and committees.

Mr. Edgerly's four Presidential Citations for services in 1972-73 brought the Association's thanks to a large number of alumni:

—**The Centennial Convocation of the Association of M.I.T. Alumnae**, for which the Association is indebted to many planners, committees, and speakers—notably to active members of the Association of M.I.T. Alumnae and their President, Miss Schur.

—**The 1973 M.I.T. Symphony Concert Tour**, the success of which was made possible by alumni committees in Chicago, Dallas, Los Angeles, Philadelphia, and San Francisco.

—**The 25th annual M.I.T. Fiesta in Mexico City**, the largest and by far the most successful of the 25-year series of early-spring alumni festivals south of the border, whose planning was accomplished by an enthusiastic committee of alumni and their wives.

—**The Class of 1923**, "possessed of a unique spirit since its undergraduate days."

Four Faculty Add Jobs in Administration

Four faculty members have taken over new administrative duties this fall:

—**Herbert S. Bridge**, Ph.D.'50, Professor of Physics who has been Associate Director of the Center for Space Research since 1964, is now Acting Director; he'll stand in for John V. Harrington, Sc.D.'58, Director, while the latter is on leave of absence as Vice President for Research and Engineering of COMSAT (the Communications Satellite Corp.). Dr. Bridge is an expert on cosmic rays and space physics, widely known for pioneering measurements of the interplanetary plasma—including mapping of the solar wind.

—**Louis N. Howard**, Professor of Mathematics, is faculty counselor for Course 25, the interdisciplinary science course which permits undergraduates in the School of Science to develop curricula matching their own interests across the range of M.I.T. departments.

—To the desk left vacant when Herman Feshbach became Head of the Department of Physics—that of the Director of the Center for Theoretical Physics—has come **Francis E. Low**, Karl Taylor Compton Professor of Physics. Dr. Low is widely regarded in elementary particle physics, and he has written a number of fundamental papers on nuclear and electromagnetic forces.

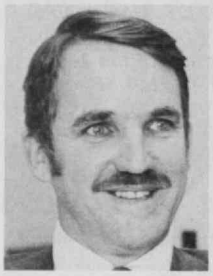
—**George C. Newton, Jr.**, '44, Associate Director of the Electronics Systems Lab-

M. S. Dresselhaus

A. P. Mattuck

L. Rodwin

G. L. Wilson



J. A. Currie

P. A. Garrison

P. J. Keohan

A. C. Tovell

oratory, is now Executive Officer of the Department of Electrical Engineering; he has administrative responsibility for details of both teaching and research programs in the Department, which is M.I.T.'s largest. Dr. Newton's research and teaching have been in instrumentation, control, and computation.

Professorships to Dresselhaus, Mattuck, Rodwin, and Wilson

Four of M.I.T.'s most distinguished professorships have new tenants:

—**Mildred Dresselhaus**, Professor of Electrical Engineering who is Associate Head of the Department, is now Abby Rockefeller Mauze Professor. The Professorship was established to bring distinguished women scholars to the Institute in 1963, and until now it has been held for short periods by a number of noted women—including Dr. Dresselhaus herself in 1967. Now the award of the chair is being made permanent.

Dr. Dresselhaus came to M.I.T. in 1960 to work in solid state physics at Lincoln Laboratory; she joined the faculty on a permanent basis in 1968 to work in the Center for Materials Science and Engineering and the Francis Bitter National Magnet Laboratory, and she was named Associate Department Head for electrical science and engineering a year ago.

—The Class of 1922 Professorship, made possible by gifts of the Class at its 40th reunion, is now occupied by **Arthur P. Mattuck**, Professor of Mathematics. The Professorship was designed to recognize and encourage effective teaching; *The Tech* in announcing the appointment said Professor Mattuck "is best known for the organization of the basic freshman calculus sequence, 18.01 and 18.02." According to his plan, teaching was—and is—in a "self-paced" mode involving several different tracks, repeatable examinations, and individual grading conferences. He won the first "big screw" award from the students that year, and Professor Mattuck recalls that "in those days it was sort of a compliment. Now it isn't quite so friendly." Professor Mattuck is also identified with M.I.T.'s freshman pass/fail grading system.

Professor Mattuck studied at Swarthmore and Princeton and came to M.I.T. in 1955 as an instructor in mathematics. In the Class of 1922 chair he succeeds Roy Lamson, who retired last year as Professor of Literature.

—**Lloyd Rodwin**, Head of the Department of Urban Studies and Planning, is now Ford International Professor; and to devote more time to the teaching and research which that appointment implies, he will relinquish the headship of the Department at the end of the current academic year.

Professor Rodwin's professional specialty is urban and regional planning for developing countries; his work has influenced many projects in Europe, Africa, the Middle East, and Latin America, and he has also helped establish urban and regional development policies of the United Nations, the Organization for Economic Cooperation and Development, and the Agency for International Development.

P. Morrison

W. J. H. Nauta

R. M. Solow

—The Philip Sporn Professorship, funded by the electric utility industry in honor of the former President of the American Electric Power Co., has been assigned to **Gerald L. Wilson**, '61, Associate Professor of Energy Processing in the Department of Electrical Engineering. It was Mr. Sporn himself who described Professor Wilson's "coming on the scene" as "a piece of good fortune for the student body of M.I.T., for M.I.T., for the power industry, and for the country."

Professor Wilson joined the faculty on completing undergraduate and graduate study at M.I.T., and he is widely recognized for work in power system simulation. As Sporn Professor, Dr. Wilson will direct the Electric Power Systems Engineering Laboratory, where his power system simulation work has been conducted; other research there includes load scheduling and restoration systems, cryogenic generators, and high-voltage transmission.

The Faculty Honors Its Own: Three New Institute Professors

The highest honor of the M.I.T. faculty went to three of its members this fall: Philip Morrison, Professor of Physics; Walle J. H. Nauta, Professor of Neuroanatomy; and Robert M. Solow, Professor of Economics, were named Institute Professors.

What that means was defined last spring by the Committee on Educational Policy and the Academic Council: the title, they said, "honors the 'great men and women' of our faculty—individuals who have shown their greatness as participants in, and contributors to, the intellectual and educational life of the Institute."

In general the number of active Institute Professors is to be limited to 12, the statement said; the selections announced this fall bring the number to nine.

Professor Morrison is a theoretical physicist of broad interests and achievements in astrophysics, cosmology, inter-

stellar communications, and the origins of life which he has effectively communicated at levels from the most experienced of colleagues through young children in science classes and the broad audience of the general press. A graduate of Carnegie-Mellon and the University of California (Berkeley), Professor Morrison was at Cornell from 1946 until he came to M.I.T. in 1964. He was associated with the Manhattan Project from 1943 to 1946 but has almost continuously since then been identified with opposition to advanced weapons development.

Dr. Nauta's contributions have been in the anatomy of the human brain, notably its systems and their interconnections, on which he is continuing pioneering work in the Department of Psychology. Born in Indonesia, he attended the Universities of Leiden and Utrecht in the Netherlands; taught there and at the University of Zurich before coming to the U.S. in 1951; and came to M.I.T. in 1964 from a dual appointment at the Walter Reed Army Institute of Research and the University of Maryland.

Professor Solow, who came to M.I.T. in 1950 after undergraduate and graduate study at Harvard, brings to economic theory a brilliance which is matched by the wit with which he discusses it. His special contributions have been to mathematical economic theory, theories of capital and economic growth and of land use, and macroeconomics.

Administration: Nine Changes

Nine appointments in the M.I.T. administration during the fall:

—**Fred A. Cammon**, who retired last July after 32 years with the Somerville Police Department, is Training Officer with the rank of lieutenant in the M.I.T. Campus Patrol. Mr. Cammon was for many years in charge of the Somerville Police Academy, of which many members of the Campus Patrol are graduates; he'll conduct in-service training at M.I.T. and help keep members of the Patrol abreast of new developments and new laws affecting their work, and his appointment makes M.I.T.'s the first university police force in Massachusetts with a full-time training officer.

—**John A. Currie**, Assistant to the Vice President for Operations, becomes Director of Finance—a new job in which he'll have responsibility for preparing the Institute's budget and for projections on which future budgets will be based. He has earlier been instrumental in establishing the computer system used for budgeting and planning and, as Assistant Dean for Administration in the School of Engineering, for resource and manpower requirements in engineering teaching and research.

—**Patricia A. Garrison** comes to M.I.T. from the Massachusetts Department of Education to help John M. Wynne, Vice President, carry out the Institute's affirmative action program. Trained in psychology, urban planning, and community development, Miss Garrison describes herself as "very concerned with the whole aspect of minority and women employment and educational opportunities."

—**Kenneth L. Hewitt**, formerly in the offset printing shop at M.I.T.'s Graphic Arts Service, is an assistant in the Office of Personnel Services, where he will help interview prospective employees.

—**Philip J. Keohan**, Associate Comptroller since 1971, is now Comptroller of the Institute. His job covers "accounting and control of the full range of financial operations of the Institute," says Stuart H. Cowen, Vice President for Financial Operations—including especially government negotiations on indirect cost reimbursement and work with the M.I.T.'s independent public accountants. He has been Assistant Comptroller since 1967 and a member of the Institute's financial management since 1954.

—**Evelyn L. Perez**, a native of Cuba who has been for more than a year Administrative Officer of the Urban Systems Laboratory, has joined the Office of Personnel Relations as a Personnel Officer. She's studying political science at Northeastern University and is active in Boston's Spanish-speaking community council.

—**Carolyn Scheer**, having been with the Dean's Office and more recently with the Education Research Center, is now a Personnel Assistant to help interview M.I.T. job applicants.

—**Warren A. Seamans**, formerly Administrative Officer for the Departments of Humanities and of Foreign Literatures and Linguistics, is now free to concentrate on what was formerly a part-time "avocational" assignment: collecting historical, visual material about M.I.T. He's now full-time Curator of Historical Collections—and as such the guardian of at least 250,000 photographs, hundreds of paintings and portraits, architectural drawings, and some more miscellaneous memorabilia.

—**Arnold C. Tovell**, formerly Editor-in-Chief at Beacon Press, Boston, now has the same post at the M.I.T. Press; he's a 1952 graduate of Harvard and has been editing books ever since.

The Three-Year Gestation of an Ad-Hoc Committee

The membership of an ad hoc faculty committee to study the possibility of faculty review of research contracts was announced to the faculty in October. The members are:

—John M. Deutsch, Associate Professor of Chemistry, not one of the professors whose names one consistently sees on faculty committees. Dr. Deutsch has been named chairman.

—Michael Modell, Associate Professor of Chemical Engineering.

—Philip Morrison, Professor of Physics, and one of the proposers of the motions that ultimately created the committee. Dr. Morrison participated in the development of the atom bomb in World War II, but refused to participate in later weapons research projects.

—Frank Press, Robert R. Shrock Professor of Geophysics and Head of the Department of Earth and Planetary Sciences.

—Harvey M. Sapolsky, Associate Professor of Political Science. He teaches a course entitled "Bureaucracy."

—William M. Siebert, Professor of Electrical Engineering. He is a member of the Research Committee of the Research Laboratory of Electronics, M.I.T.'s largest laboratory.

—Nathan Sivin, Associate Professor of the History of Science.

The three-year gestation of the ad hoc committee was chronicled in *Technology Review*, October/November, pages 94-97.

In a Critical Year for Food, an Award and a Professorship

When Walter A. Mercer made his three-mile hike to school across the prairies near Comanche, Texas, some 50 years ago, his lunch pail often held a sandwich of Underwood Deviled Ham. But as a Texas farm boy—or even as a bacteriologist for the National Canners Association—he never expected his newest exposure to that product: the Underwood-Prescott Memorial Award and Lectureship of M.I.T., given on September 25 to commemorate Mr. Mercer's many contributions to the U.S. food industries.

It was the eleventh award sponsored for M.I.T. by the William Underwood Co., and George C. Seybolt, President of the Company, pledged its continuing support for a second decade of Underwood-Prescott Awards. The idea, he said at the award luncheon, is that "one should put more into the world than he takes out."

Walter A. Rosenblith, Provost of M.I.T., gave Mr. Mercer his scroll and $1,000 honorarium—and announced that over $650,000—including a "generous challenge pledge of $300,000" from the Underwood Co.—was now available to support the Underwood-Prescott Professorship; can the full $750,000 goal be met by the time of the 12th award? he asked.

Mr. Mercer is Vice President of the National Canners Association and Director of its Western Research Laboratory at Berkeley, Calif. His work for the N.C.A. has been "central to increasing the productivity of food processing" said Samuel A. Goldblith, '40, the Underwood-Prescott Professor of Food Science.

Will productivity increases continue in the future? They must, said Professor Goldblith; but 1973 has been "a critical year for the food industry"—because rising consumerism has been supported by increasingly stringent federal regulation, and because rising costs have squeezed the industry's profit margins.

Mr. Mercer studied at the Universities of Arizona and California (Berkeley) and joined the National Canners Association as a bacteriologist in 1950. He is now also Director of the University of California's Laboratory for Research in the Canning Industries, and he is considered an authority on the use and conservation of water in the farming and food industries.

Walter A. Mercer (right) said he found himself "overwhelmed" when Walter A. Rosenblith, Provost, gave him M.I.T.'s 1973 Underwood-Prescott Award. Then he proceeded to a symposium in his honor, where he demonstrated the critical role of water in food production and called for realistic national and industrial plans for water conservation (see p. 71).

Raisins "Dried Up," But "We're Eating Real Good"

When you're feeding a family of 1,000 growing boys and the price of steak goes up to $1.98/lb., what then?

No steak.

But no real problems, either, according to a survey of fraternities and the M.I.T. Dining Service by Robert H. Halstead, '76, for *The Tech* this fall. "The higher prices are simply being swallowed," he said.

Only one of five fraternities whose stewards were queried was "cutting back seriously" on food. There will be no steak or roast beef, no bacon or sausages in that house. Another has switched from lean to regular hamburger, and 'the brothers are being encouraged to voluntarily cut down on milk drinking." But basically "the house is willing to pay" whatever it costs to eat well.

"We could be $4,000 in the hole, but right now we're eating real good," another steward told Mr. Halstead. A third, reporting that the house policy was one of "paying more rather than eating less," said this year's food budget was $78 per man per month, compared to about $67 last year.

Harmon E. Brammer, Director of Housing and Food Services, takes a similar "grin and bear it" attitude for on-campus dining rooms. There have been some price increases, and some items have been taken off the menus. But the dining rooms have one big—and unexpected—advantage: instead of an estimated 700 students on "commons" (contract) meals, the figure early in the first term was 791. A problem, too, with voluntary "commons": almost everyone eats all the meals he contracts for (Harvard, with a compulsory plan, expects only about 75 per cent of contract meals to be eaten), and "we get all the big eaters," said Mr. Brammer.

In three months since July institutional food prices in Boston went up anywhere from 20 to 50 per cent on selected items—25 to 35 per cent on beef and pork, 50 to 60 per cent on chicken, 25 to 30 per cent on eggs, 40 per cent on salad oil. And "the supply of raisins has completely dried up," Mr. Brammer told *The Tech*.

You wanted the passport used by General Francis Amasa Walker, who was President of M.I.T. from 1881 to 1897? The Vassar class pin that belonged to Ellen Swallow Richards ('73), M.I.T.'s first coed graduate? Apply to Warren A. Seamans, newly-appointed Curator of Historical Collections, who is also the custodian of 250,000 photographs, several hundred portraits and paintings, and a miscellaneous collection of other objects from the Institute's past.

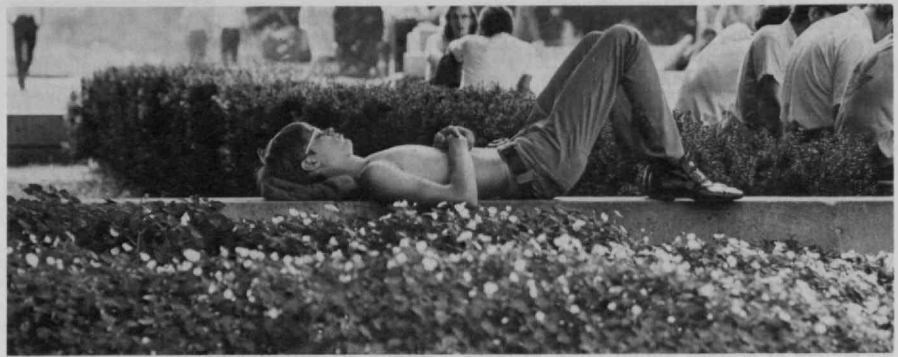
The Class of 1977. . .

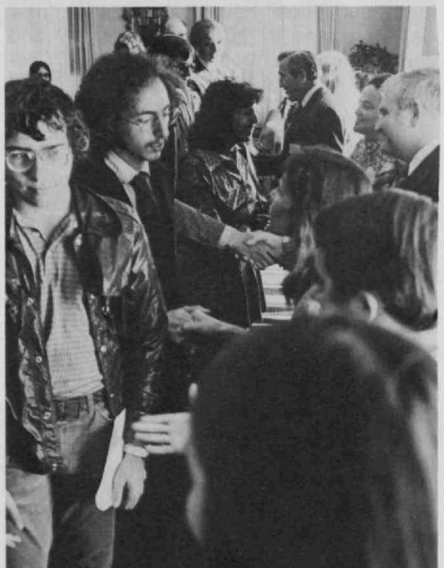
. . . has 908 members, of whom 125 are women and 46 are from minority groups. The percentage of women is a new high for the Institute, though it is not the largest number of women ever in an entering class.

M.I.T. received 3,813 final applications, made 1663 offers of admission, and ended up eight students away from its goal: a freshman class of 900. The size of the entering class is smaller than M.I.T. would like, but it is required by the shortage of on-campus housing, caused by the enormous popularity of the Institute's dormitories among upperclassmen, very few of whom have chosen to move off campus.

M.I.T. President Jerome B. Wiesner told the entering class exactly what he told the entering class last year: that they "are bucking the conventional mood by choosing a science-oriented career, for many people are attacking science and engineering as the basis of most of society's problems."

"We feel strongly," Dr. Wiesner said, "That in the future, engineers and scientists . . . must have an important part in the continuing evolution of our society. We hope that an M.I.T. education will equip you for such a role, not only with an unexcelled technical education but with a sense of personal confidence, an unshakable integrity, the courage to pioneer, and a respect for others."





If you were a member of the M.I.T. Class of 1977, you spent one of the hottest weeks of the summer in Cambridge early in September, coming to know your new classmates and the Institute to which you were to devote the next four years. A leisurely schedule and a sense of informality generated by the weather combined to give the activities of freshman orientation a kind of casualness often missing in earlier years; indeed, one of the few traditional events was the reception by President and Mrs. Jerome B. Wiesner and Chancellor and Mrs. Paul E. Gray ('54) for students and their parents on September 9 (left). (Photos: Sheldon Lowenthal, '74)

Increasing Productivity: More Students or More Throughput?—The Sloan School's Choice?

What did Chancellor Paul E. Gray, '54, have in mind when he told the faculty that increasing M.I.T.'s productivity would be a necessary response to the Institute's future financial problems (*see p. 97*)?

Pressed by the faculty at its October meeting, President Jerome B. Wiesner speculated on the leverage of the tuition income from 1,000 extra students—over $3 million at current tuition rates, at least $200,000 a year if tuition continues to rise 6 per cent annually as it has in the recent past.

Was he serious? Probably not, if his postulate of 1,000 more students be taken literally. But he assured the faculty that increasing enrollments in some amount were very much in his mind; for example, he cited Admissions Office studies to propose that there are plenty of high school graduates qualified for M.I.T. who are not now coming—or even applying. "The pool is substantial," he said; "we're not now tapping by any means all of it."

Using the Campus Year-Around

Another obvious alternative is year-round use of classrooms and laboratories, and for that there is a little-known two-year precedent at M.I.T.: the Accelerated Graduate Program of the Sloan School of Management.

In a nutshell, the Program gives "highly motivated" students a chance to complete seven of the eight core subjects in the Sloan School's Master's Program during a summer term from June through August. Then they continue with a somewhat heavier-than-normal load during the academic year (ten subjects *plus* thesis), and by June—just 12 months from the time they entered the Program—they receive the School's Master's Degree.

Students in the regular Master's Program of the Sloan School take four academic terms—two years—to cover the same ground.

If you think the one-year program sounds fairly intensive, you're right. The School admits it is "unusually demanding," but there have been some "new developments in curriculum design and pedagogical method" which help, especially in that concentrated summer term.

In its first experimental year (1972-73) 32 students signed up for the 12-month Accelerated Graduate Program; most of them had several years' of nonacademic experience since receiving their earlier degrees and so were, as the Sloan School expected, somewhat more mature than the typical Master's Program students. There are 27 registrants with similar backgrounds in the 1973-74 Program, and the School is now seeking applicants for a group about the same size to start in June, 1974.

What are the results? Too early to be sure, of course, since the ultimate proof will be measured in terms of the graduates' careers over many years. But Thomas M. Hill, Associate Dean for Administration, is confident; he believes the accelerated program is "a major step towards increased cost-effectiveness in professional education."

For a detailed preliminary evaluation, the Sloan School asked three members of its staff—Ronald E. Fry, S.M.'71, Pierre-Yves J. Lejeune, S.M.'72, and Assistant Professor Irwin M. Rubin, Ph.D. '66—to follow the program and obtain the students' reactions to it. If the results—which are admittedly preliminary, based on short-range data—prove valid, the experiment may speak critically to the large issue of how education in and out of the classroom does in fact contribute to professional competence and maturity.

Why Do in Two What Can Be Done in One?

Surveying the first summer program in 1972, Professor Rubin and Mr. Fry found the students fully convinced that they were an elite group, experimenting with a new and presumably innovative program. But in fact, thought the researchers, the curriculum innovations promised by the School were hardly realized; in some cases there was very little change from the regular format; in others the changes were extensive but more "related to the time and scheduling constraints (than) to interest in offering a new [self-paced] learning style."

The students expected to work hard and to be rewarded with an educational experience that would be "fun and exciting." But most "had as much or more free time than they expected, did as much or less work than they expected, and found the pace did not affect their learning; but they found the program less fun and exciting than expected."

In the fall term, when the students had behind them what was expected to be the most intensive part of their experience (almost all of two regular terms work in one summer term), Mr. Lejeune said the group felt they had more work than in the summer, that "the pace was more hectic than before."

Indeed, as the summer term ended Mr. Fry and Professor Rubin found the faculty asking a tough question: if the accelerated, one-year program is in fact do-able, then why continue the two-year Master's Program at all?

Why Few Blacks in Science? Because There Are So Few

Shirley Jackson, '68, was one of five blacks (two women) in her freshman class at M.I.T. nearly a decade ago. Now she's finished her Ph.D.—in elementary particle physics—and is busy with post-doctoral work at the National Accelerator Laboratory in Batavia, Ill.

Why so few blacks like her in science and engineering? asked Ginny Pitt of the Associated Press just before Miss Jackson left Cambridge.

Mostly, thinks Miss Jackson, because there are "no role models"; the scarcity is self-perpetuating. Though she never doubted her ability to become a good physicist, Miss Jackson thinks that "because you don't find black women in visible, significant positions within the academic community, you begin to wonder if it's possible."

R. Landau

In nine years at M.I.T., she told Miss Pitt, she came in contact with only a handful of black male professors and a few white female professors and administrators. There were no black administrators when she came, and no black female professors.

Though a lot of people have told Miss Jackson that she's "lucky" to be black and female now "because blacks and women are in vogue for employers," she insists that's not the point. "I want to be a good physicist," she says, "to make a contribution in physics and in education." And she wants to be a role model: "If I can serve as an example to others, even though that's not my first goal, it will certainly help."

Landau: "A Technological Entrepreneur of the First Rank"

To a substantial collection of laurels for achievements in the chemical industry, Ralph Landau, Sc.D.'41, has now added the capstone: the 40th Chemical Industry Medal of the Society of Chemical Industry, awarded at the Society's medal dinner in New York on October 3.

"A technological entrepreneur of the first rank" was the tribute to Dr. Landau by Howard W. Johnson, Chairman of the M.I.T. Corporation, who introduced the awardee for the address of the evening.

"To make industrial progress—and hence social progress," said Mr. Johnson, "one needs both technical ideas of high quality and entrepreneurship of high quality—people of great technical competence and vision and people who are creative and innovative managers.

"To find these qualities combined at the highest level in a single person is most rare."

Dr. Landau chose chemical engineering when he entered the University of Pennsylvania in the 1930s. An article in the *Philadelphia Evening Bulletin* said chemical engineering was "a new profession with a promising future," Dr. Landau recalled for *Chemical and Engineering News* this fall. "That sounded good when the entire world was crashing."

By 1941, when he finished his doctorate at M.I.T., the situation was a bit different. Dr. Landau went to work for M. W. Kellog Co., shortly becoming head of the Chemical Department of its Kellex Corp. subsidiary responsible for building the first plant to separate uranium isotopes by gaseous diffusion. At the end of the World War II he founded Scientific Design Co., Inc., a process development and engineering construction company; seven years later enough capital was accumulated to take the big step of entering chemical manufacturing through Halcon International Corp.

In both cases, said Mr. Johnson, Dr. Landau's success was based on his ability to lead development of "radically new technology." For example, 5.3 billion lbs./yr. of terephthalic acid—the majority of the free world's basic raw material for polyester fibers—is now made by the Mid-Century Process developed at Scientific Design and Halcon and now owned by Standard Oil Co. (Ind.), and Halcon has also developed other important polyester and nylon intermediates. Meanwhile, says *Chemical and Engineering News,* Scientific Design Co. has engineered more than 200 plants worldwide and has licensed its technology to more than 100 companies.

Indeed, said *Chemical and Engineering News,* a "special patina on the award comes from the considerable range of Dr. Landau's achievements; . . . (he has) integrated an exceptional range of talents in his career." These, says *C. & E.N.,* include not only process engineering but mathematics and systems analysis, business organization, and languages . . .

. . . the latter because much of Scientific Design's first work was outside the U.S., where World War II had left industries in desperate need of new or rebuilt plants. Dr. Landau has been to Europe no less than 59 times, to Japan eight times, to Australia twice—and in the process seven times around the world.

Eugenio Garza Sada, 1891-1973

Don Eugenio Garza Sada, '14, a prominent Mexican industrialist who founded the Instituto Tecnologico de Monterrey in the image of his alma mater, was the victim of political violence in Monterrey, Mexico, on September 18. He was 82.

Mr. Garza was shot to death, along with his chauffeur and one of his business associates, when they offered resistance to would-be kidnappers on a busy Monterrey street. The attack could hardly have been unexpected; Monterrey businessmen said that terrorists arrested in the past had put Mr. Garza high on their list of future targets in their effort to promote the revolutionary cause.

Fourteen factories and business houses in which Mr. Garza had substantial interests were reported closed on September 19 in Monterrey in tribute to him; and as a mark of his personal concern Luis Echeverria Alvarez, President of Mexico, directed that his Ministers of Education and of Industry and Commerce attend the funeral—and also attended himself.

Eugene McDermott, 1899-1973

Eugene McDermott, former President of Texas Instruments, Inc., a Life Member of the M.I.T. Corporation, and a philanthropist with broad interests in education, science, and the arts, died in Dallas, Tex., on August 24 following a long illness. He was 74.

Howard W. Johnson, Chairman, wrote to his colleagues on the M.I.T. Corporation that Mr. McDermott had for 10 years "set an outstanding example of trusteeship and service to the Institute.

"In countless ways he unselfishly advanced the strength and quality of M.I.T.'s research and educational program, both as a trusted friend and adviser to M.I.T. presidents," Mr. Johnson said.

Similarly generous tributes came from literally around the world. In Dallas Cecil H. Green, '23, who—like Mr. McDermott—is a former Chairman of the Board of Texas Instruments, Inc., was quoted: "He was a very human and fair-minded man with a very high level of integrity. . . . He was a good judge of people." And Eric Jonsson, former Mayor of Dallas who was with Messrs. McDermott and Green a founder of Geophysical Services, Inc., in 1930, described him as "simply the sort of man (on whom) you could bet your life every day of the week and not worry. . . . He wanted to know what made things tick, why people act as they do. . . . When he found some answers, he'd try to use them to inch the society a little further along to something better."

It was in 1960 that Mr. and Mrs. McDermott gave M.I.T. Texas Instruments, Inc., stock then valued at $1.25 million to create the largest named and endowed undergraduate scholarship fund at the Institute. In 1964 the 300-seat lecture hall in the Cecil and Ida Green Building was designated McDermott Hall; and in 1966, through the generosity of Mr. and Mrs. McDermott, the McDermott Court with Alexander Calder's "Big Sail" sculpture "opened a new era of concern for the beauty and aesthetic development of the campus," Mr. Johnson said.

Mr. McDermott, born in Brooklyn, N.Y., studied at Stevens Institute of Technology and Columbia University; his two partners in the founding of Geophysical Services, Inc., describe him as the "scientist" of the three, Mr. Green characterizing himself as the "field man" and Mr. Jonsson as the manager. Mr. McDermott became its President when Texas Instruments, Inc., was founded in 1939 to become the parent company of G.S.I., and he served a total of 33 years on T.I.'s Board of Directors.

But Mr. McDermott's career as fine arts patron and philanthropist will be at least as well remembered—in Dallas and throughout the U.S.—as his contributions to geophysical oil exploration and—more recently—diversified electronics manufacture. Among many beneficiaries were Southern Methodist University, the Dallas Museum of Fine Arts, the Graduate Center for the Southwest (now the University of Texas at Dallas), St. Marks School of Texas, the Dallas junior college system, Hockaday School in Dallas, the Southwestern Medical School of the University of Texas, Stevens Institute of Technology, and countless more.

William W. Wurster, 1895-1973

William W. Wurster, '17, a distinguished architect who was Dean of M.I.T.'s School of Architecture and Planning from 1944 to 1950, died on September 19 in Berkeley, Calif. He was 77.

He left M.I.T. to become Dean of the College of Architecture of the University of California at Berkeley, and nine years later he became founder and Dean of the University's new College of Environmental Design; in the latter, says William Wheaton, that College's current head, Dean Wurster "anticipated by a decade the current concern for the environment."

At the same time, Dean Wurster contributed individually and through his firm—Wurster, Bernardi and Emmons—to designing such West Coast landmarks as the Bank of America world headquarters, major parts of the Golden Gateway Center and Ghirardelli Square, and the Center for Advanced Studies in Behavioral Sciences at Stanford. It was in 1963, when he retired from the University of California, that Dean Wurster said, "Architecture is a corridor with many doors, opening into all aspects of humanity. It joins together many, many forces. I do not believe in embalming ideas. We none of us, architects or others, have the privilege of building monuments to ourselves. Our work must be for people."

At M.I.T. Dean Wurster elevated city planning from a division to a department, recognizing it as a separate profession having its own body of competence. He brought the distinguished Finnish architect Alvar Aalto to the Institute as a teacher and championed his design for Baker House, the only Aalto-designed building in the U.S. And his emphasis on technology in relation to architectural design was prophetic of a new design philosophy for the School and for the nation.

Born in Stockton, Calif., Dean Wurster studied at the University of California and practiced architecture in San Francisco until 1943, when he came to Harvard to study city planning. He was married in 1940 to the late Catherine Bauer, already a national known expert in public housing and planning.

Individuals Noteworthy

Philip Morrison, Professor of Physics, M.I.T., has been elected Chairman of the Federation of American Scientists. Two other M.I.T. faculty have been named to four-year terms on the council of the Federation: **David Baltimore**, Professor of Biology and **Francis Low**, Professor of Physics.

Samuel A. Goldblith, Underwood-Prescott Professor of Food Science at M.I.T. and associate head of M.I.T.'s Department of Nutrition and Food Science, has been elected a public member of the board of trustees of the Nutrition Foundation. . . . **Walter A. Backofen**, '46, M.I.T. Professor of Metallurgy and Materials Science, was chosen to present the 1973 Edward DeMille Campbell Memorial Lecture in Chicago during the American Society for Metals' 1973 Metal Show and Materials Engineering Congress in October. . . . **Thomas E. Nutt**, Instructor at M.I.T. Department of Urban Studies and Planning, has been elected as a member of the Board of Governors of the American Institute of Planners.

Three additional members of the faculty of M.I.T. have been elected Fellows of the American Academy of Arts and Sciences: **Daniel J. Kleitman**, Professor of Mathematics, to a Fellow in the Academy's Mathematics Section; **James C. Keck**, Professor of Mechanical Engineering, to a Fellow in the Engineering Sciences and Technologies Section and **Benson R. Snyder**, Professor of Psychiatry and Architecture and Planning, to a Fellow in the Medicine Section.

Awards and Honors

Seven $500 awards were presented to outstanding teachers on the academic staff in the Department of Electrical Engineering. The teachers are: **Barry Blesser**, '64 and **Gary Montress**, '69. Similar awards were given in behalf of Supervised Investors Services, Inc., to four teaching assistants and one instructor. **Joseph Qualitz**, '70 and **Robert Turek**, '70 were recipients. **P. L. Thibaut Brian**, Sc.D.'56, Vice President and Director of Air Products and Chemicals, Inc., received the 1973 Professional Progress Award in Chemical Engineering pre-

sented by the American Institute of Chemical Engineers. Professor **David M. Epstein**, Conductor of the M.I.T. Symphony Orchestra, has been chosen as one of the recipients of a 1973-1974 Award from the American Society of Composers, Authors and Publishers. . . . The National Medal of Science was presented at the White House to **Harold E. Edgerton**, '27 and **Vladimir Haensel**, '37. Dr. Edgerton "For his vision and creativity in pioneering in the field of stroboscopic photography and for his many inventions of instruments for exploring the great depths of the oceans." Vladimir Haensel "For his outstanding research in the catalytic reforming of hydrocarbons which has greatly enhanced the economic value of our petroleum natural resources. . . . The fortieth award of the Chemical Industry Medal was presented to **Ralph Landau**, Sc.D.'41, by the American Section, Society of Chemical Industry. . . . **William M. Murray, Jr.**, M.S. '55, has received the Dr. William E. Upjohn Award from The Upjohn Company. . . . **M. Bradford Snyder**, '64, was presented with the Mark Mills Award by the American Nuclear Society for his outstanding paper, "Optimal Control Rod Policies for an Operating Cycle of a Simulated Boiling Water Reactor Core." . . . **John G. Zarcaro**, '54, was awarded the N.A.S.A. Exceptional Service Medal.

Corporate Appointments

Louis B. Barber, '46, has assumed joint ownership of Henry L. Wolfers, Inc. . . . **Eric S. Beckjord**, S.M.'56, has been appointed Director of Uranium Enrichment Operation of Westinghouse Power Systems Co. . . . **Robert O. Bigelow**, '49, has been appointed Director of Planning and Power Supply for New England Power Service Co., a subsidiary of New England Electric Systems. . . . **Francis "Jack" Bittel**, '40, has been named General Manager of Marketing, Youngstown Sheet and Tube Co. . . . **George A. Bobelis**, S.M.'58, has been named President of Reed Rolled Thread Die Co., a division of Litton Industries. . . . **E. D. Boston**, S.M.'49, has been named Planning and Coordination Manager of the Paramins Department of Exxon Chemical U.S.A. . . . **James W. Brown**, '54, has been elected Executive Vice President, General Manager and a member of the Board of Directors of Austin Powder Co.

John O. Hartung, '60, was appointed Vice President and Director of Wood Products Operations for ITT Rayonier, Inc. . . . **Thomas Johnson**, '24, has become Textron Inc.'s Welsh Division's new Chairman. . . . **Raymond W. Ketchledge**, '41, has been named Executive Director of the Local Electronic Switching Division of Bell Laboratories. . . . **David H. Klipstein**, Sc.D.'56, has been appointed to the new position of Assistant to the President of Oxy-Catalyst, Inc., a subsidiary of Research-Cottrell, Inc. . . . **George E. Kostritsky**, M.C.P.'51, and **Richard C. Stauffer**, M.A.R.'58, have announced the formation of a new firm, Architecture Planning Research/Associates in Washington, D.C., providing professional services in architecture, urban design and planning, and environmental research. . . . **Benjamin Lax**, Ph.D.'49, M.I.T. Professor of Physics and Director of the Francis Bittner National Magnet Laboratory, has been elected to the Board of Directors of Infrared Industries, Inc.

Henry A. Lichstein, '65, has been named Vice President in First National City Bank's Financial Reporting and Profit Planning Division. . . . **W. E. Littmann**, Sc.D.'52, has been promoted to the position of Manager-Metallurgical and Mechanical Research at the Timken Co. . . . **Charles J. Lucy**, '50, has been appointed Manager of the Telecommunication Products Department, and **George W. McKinney**, 3rd, '65, Manager of Financial Analysis and Planning at Corning Glass Works. . . . **H. Jack Maier**, '54, has been appointed Executive Vice President at Thermo-Lab Instruments, Inc. . . . **LeRoy Malouf**, '54, has been appointed Vice President, and **Dorian Shainin**, '36, to Senior Vice President of Rath and Strong, Inc. . . . **Russell Murray**, 2nd, '49, has been named Director of Review at the Center for Naval Analysis. . . . **William R. Oakes**, '56, has been appointed to the newly created post of Vice President in charge of Marine Systems for Marine Management Systems, Inc.

Richard E. Quinn, '56, has been appointed as Director of Finance and Technical Services of R.C.A. Laboratories. . . . **Lawrence G. Roberts**, '59, has joined Telenet Communications Corp. as President and Chief Executive Officer. . . . **Lawrence R. Rojahn**, '61, has been promoted to Vice President of Research and Development of Superior Continental Corp. . . . **H. Kenneth Spaulding**, '41, has been appointed Manager of American Smelting and Refining Company's new copper refinery to be erected at Amarillo, Texas. . . . **Robert C. Sprague**, S.M.'23, was elected a member of the Executive Committee of Mitre Corp. . . . **George L. Stallman**, 3rd, M.C.P.'64, has announced the opening of George L. Stallman Associates, Inc., a firm which will provide planning and design services to both private and public agencies. . . . **Carroll G. Thompson**, S.M.'69, has been promoted to a new position of Manufacturing Manager of R. J. Reynolds Tobacco Co. . . . **Peter Viemeister**, S.M.'69, has been appointed Vice President of Development by the Board of Directors of Grumman Corp.

Alvin G. Waggoner, '42, has been appointed Vice President in charge of Financial Management and Administration for Cutler-Hammer's A.I.L. Division. . . . **T. F. Walkowicz**, '41, has been named Chairman and Chief Executive Officer of National Aviation Corp. . . . **Seth H. Washburn**, '44, has been appointed Executive Director of the Salary and Technical Personnel Administration Division of Bell Laboratories. . . . **Robert L. Wilcox**, S.M.'55, has joined the international consulting firm of Daniel, Mann, Johnson and Mendenhall, in Los Angeles, as Vice President and Chief Sanitary Engineer. . . . **Howard Wing**, '53, has been appointed Director of Corporate Development of Tyco Laboratories, Inc. . . . **Theodore B. Winkler**, Sc.D.'48, has been elected Assistant Vice President in Bethlehem Steel Corporation's Research Department.

Deceased

Ambrose F. Bourneuf, '02, June 13, 1973
William C. Twieg, '03, September 23, 1968
Walter G. deSteiguer, '06, February 16, 1973
Cecil F. Baker, '07, September 14, 1973
Herbert H. Palmer, '09, April 9, 1973
Harvey S. Pardee, '09, June 15, 1971
John C. Stevens, '09, April 11, 1973
Allen A. Gould, '10, October 2, 1973
Frederick T. Alden, '12, October 3, 1973
Howard J. Cather, '12, July 1, 1973*
George M. Sprowls, '12, June 25, 1973
John H. Hession, '13, May 11, 1973*
William L. McPherrin, '14, July 12, 1973
Walter B. Rivers, '15, October 1, 1973
Charles F. Cellarius, '16, September 8, 1973*
Frank B. Hastie, '16, August 13, 1973*
Ralph A. Spengler, '16, June 26, 1973
William L. Campion, '17, September 6, 1973
William B. Colleary, '17, August 18, 1973
Erasmus G. Senter, Jr., '17, August 22, 1973
William W. Wurster, '17, September 19, 1973
George R. Pierce, '18, February 2, 1973
Edwin F. Rossman, '18, May 8, 1973
Franklin S. Adams, '19, August 8, 1973
John W. Meader, '19, August 1, 1973
Carley H. Paulsen, '19, August 2, 1973
Edward L. Sache, '19, April 4, 1972
Harry A. Zimmerman, '19, October 9, 1973
Wilford P. Hooper, '20, February, 1972
John M. Nalle, '20, July 23, 1973*
John C. Nash, '20, September 25, 1973*
Edwin S. Lockwood, '21, July, 1973
Willard G. Loesch, '21, June 18, 1973
Dexter N. Shaw, '22, July 25, 1973*
Robert S. Coupland, Jr., '23, June 27, 1973
E. Louis Greenblatt, '23, July 31, 1973
John H. Neher, '23, June, 1973
Percival S. Rice, '23, September 13, 1973*
H. H. Zornig, '23, July 11, 1973
T. Richard Rhea, '24, September 16, 1973*
Samuel Shulits, '24, February, 1973*
Dana R. Staples, '24, November, 1972*
William H. Van Dusen, '24, July 21, 1973
Frederick W. Cunningham, '25, January, 1973
Cornelius J. Enright, '25, July 5, 1973
John E. Deignan, '26, July 13, 1973
Lauchlin Gillis, '26, June 4, 1973
Howard W. McCue, '26, July 18, 1973
Robert W. Richardson, '26, October 5, 1973
Edward R. Vose, '27, July 24, 1973*
Haskell C. Needle, '28, October 7, 1973*
Ernest R. Famiglietti, '29, August 3, 1971
Roger W. Tarbox, '29, December 5, 1972
Holland W. Hamilton, '30, September 3, 1973
James J. Mazzoni, '31, March 30, 1973
Albert R. Pierce, Jr., '31, September 22, 1973
Gordon D. Shellard, '31, July 13, 1973
Harry L. Moore, Jr., '32, September 10, 1973*
Chauncy W. Raycroft, '33, February, 1973
Richard E. Wheeler, '33, February 6, 1973
Dane E. Wells, '34, September 12, 1973
Edwin R. Millen, '35, July 4, 1973
Wilfred H. Rapport, '35, September 26, 1972
Daniel B. M. Finucane, '36, August 30, 1973
Quentin Berg, '37, July 20, 1973
James G. Loder, '37, May 7, 1973*
William W. Preston, '38, November 22, 1969
Frank E. Plumley, '40, September 21, 1973
A. Ward Wood, '40, February 9, 1972
Francis E. Vinal, '41, October 10, 1973
Bernard B. Helfand, '43, June 5, 1973
Wallace S. Frank, '47, September, 1968
John B. Seabrook, '49, July 29, 1973
Richard W. Warren, '49, July, 1971
Leonard H. Caro, '50, May 15, 1973
Edward C. Chase, '50, September 21, 1973
Richard T. Keller, '50, October 20, 1973
Donald R. Newhouse, '50, October 18, 1973
Franklyn N. Greene, '51, September 8, 1973
Ernest A. DiPasquantonio, '51, July 16, 1973
Alan H. Stenning, '51, October 19, 1973
Haig Marzbanian, '53, November 28, 1971
Vahan V. Terzian, '53, December, 1969
Lewis E. Russell, '55, July 29, 1973
John S. N. Daniel, '56, December 13, 1972
Robert J. Cummings, '64, July 31, 1973
Henry H. Nester, '64, October 7, 1969
John B. W. Greene 4th, '66, March 4, 1972
Peter M. Stephenson, '69, September 7, 1973
Gordon Woulff, '72, July 27, 1973
*Further information in Class Review

The Editors express their apologies for mistakenly reporting Don Coppersmith, '72, as deceased in the July/August issue.

Class Review

96

A very special birthday was celebrated on October 23 when Dr. **William D. Coolidge** '96 reached the century mark. Your Secretary took advantage of the Veterans' Day weekend to call on him in Schenectady and add the congratulations of the Class to the many messages received from all corners of the globe. Actually there was a two-day celebration with a family party and a special colloquium on the day preceding the official birthday dinner arranged by the Research Laboratory of General Electric for their long-time director. Real progress in the design of birthday cake illumination was demonstrated. One hundred tiny electric light bulbs were around the circumference and in the center was a larger "candle"—to grow on. Its sparkle came from a sample of crystalline carbon which was in a setting containing 100 smaller crystals, G.E.'s birthday present to Dr. Will.—**Clare Driscoll**, Acting Secretary, 2032 Belmont Rd. N.W. Washington, D.C. 20009

Centenary Celebration. Dr. William D. Coolidge, '96, famed inventor of the ductile tungsten used for filaments in virtually all electric lamps and of the Coolidge X-ray tube which made possible modern medical and industrial X-ray technology, observed his 100th birthday in Schenectady, N.Y., on October 23. Dr. Coolidge joined the staff of the General Electric Research Laboratory in 1905, and was its director from 1932 to 1945. He was succeeded by Dr. C. Guy Suits (right), director until 1965, and by Dr. Arthur M. Bueche (left) who became G.E.'s vice president for research and development when Dr. Suits retired. The birthday cake was lighted with 100 ductile-tungsten lamps and topped by the target from an early Coolidge tube encrusted with 100 tiny diamonds surrounding one of G.E.'s large laboratory-made gem diamonds.

98

Christmas greetings to the oldest Alumni of M.I.T. You very special members on this Honor Roll are **Al Davis**, **Bob Lacy** and **George Newbury** who, incidentally, has a change of address, 210 Morris Lane, Hendersonville, N.C. 28739. His daughter, Mrs. Buckley, wrote to me as follows; "My daughter had a new home built with most of the cellar made into a nice apartment for my father and me. We had a busy summer with selling my house, moving, and since this house is further out of town I had to learn to drive a car. Finally was able to pass the tests and can drive now. My father is getting used to the new apartment. He no longer needs someone to watch him when I go out for Bonnie is right upstairs and comes down to look at him often. This is one of the best retirement places in the U.S. Why haven't you come here?" End of quote. Mrs. Buckley knows, as I previously told you, that Harold and I enjoy trailering in our retirement. We sold our home in October, and please note that the address is now—**Mrs. Audrey Jones Jones**, Acting Secretary, P.O. Box 294, Forest Park Station, Springfield, Mass.

99

Our Classmate, Professor **Frederick W. Grover**, died on January 30, 1973. In his active years, he was a professor at Union College, Schenectady, N.Y., where he continued to live after his retirement.

However, a few years ago he moved to Lynn, N.C., in order to escape the severe winters of New York and to be near his married sister.

He was very fond of domestic and foreign travel.—**Norman E. Seavey**, Acting Secretary, Apt. 514, Lucerne Towers, Orlando, Fla. 32801

02

As a class, because of our small number, there is little or no change of address of its members, however **Carlton Allen** has jumped from Larchmont, N.Y. to Ohio. His present address is 23351 Chagrin Blvd., Cleveland, Ohio 44122. . . . **Arthur Collier** reports he has summered well. He was 94 in September. I hope you all have

W. W. Pagon, '07

a merry Christmas and a happy 1974—**Burton G. Philbrick**, Secretary, Greycroft Inn, 68 Dane St., Beverly, Ma. 01915

03

A recent article in a local newspaper noted that a $1.1 program by the National Science Foundation is being made available to universities. Hopefully this will stimulate future Edisons, Fords and Wrights in the university environment. After long and busy careers our retired classmates in their varied engineering employments have made many valuable contributions to society. Accordingly classmates, bring forth your ideas or suggestions and have them evaluated by our M.I.T. "Innovation Co-op."

Along the line of innovations we note that Arthur D. Little, Inc., has explored the potential of solar heating and cooling of buildings. This should be a new element in future architectural design and building construction.

We have two new addresses: **Philip B. Rice**, Course VI, P.O. Box 446, Blue Ridge Summit, Penna. 17214 and **Jay B. Simon**, Course III, 1045 Pennsylvania Ave., Denver, Colo. 80203.—**John J. A. Nolan**, Secretary-Treasurer, 13 Linden Ave., Somerville, Mass. 02143

07

Mt. Holyoke's September Alumni magazine gave mention of **Frank S. MacGregor**, an honorary member of the Class of 1910 at that Institution. Mr. MacGregor presented $500,000 to Mount Holyoke to establish the Frank S. and Elizabeth Marshall MacGregor Endowment Fund. The income from the fund is to be used for Faculty support and Library acquisition of books and other materials in any field of recorded knowledge.

W. Waters Pagon passed away October 24, 1973. He was a retired civil engineer and a native of Baltimore. Mr. Pagon graduated from Johns Hopkins in 1905, M.I.T. in 1907 and later received a master's from Harvard University in 1910. He held the rank of captain in the Corps of Engineers in World War I. In the Second World War he served on the War Manpower Commission. He was a lecturer at Johns Hopkins and did much to development its School of Engineering there.

Mr. Pagon had an active and pioneering interest in the development of aircraft and published extensively on the science of aeronautics and aircraft construction and engineering in general. In 1928 he won the Federal Bureau of Aviation Award for a design of a rigid airship, and several years later he was awarded the American Society of Civil Engineers' James Laurie Prize for a paper entitled, "Transatlantic Seaplane Base, Baltimore, Maryland."

He is survived by his wife, the former Katharine Dunn; a son, Hugh Pagon, of Washington, and seven grandchildren.—**Margaret Kelly**, Alumni News Editor, E19-430, M.I.T. Cambridge, Mass. 02139

11

A Merry Christmas, 'Lev'ners, all,
May joy be all around,
May only what is good befall
And happiness abound.

Frank Smith of Honolulu sent me the following comments on an article that appeared in the June *Review:* "I read Mr. Hodge's article on 'Farming the Ocean' and the last sentence intrigued me. 'Rainbow trout under controlled conditions may grow to almost 7 pounds in 18 months or about 15 times what a wild trout would be at the same age.' This I don't doubt, but tell me, what would such a bred trout taste like when fried. I say about one fifteenth of the flavor of a wild trout of the same age. Now and then we have 'trout' on the bill of fare; trout grown in Japan, frozen and shipped here. I've also eaten the same rainbow trout grown in the U.S.A. and, if I could not see, I would never know I was eating fish, especially a trout. Not even TROUT raised in a technical world keep the identity (taste) of natural trout. Give me the trout every time, ten if necessary, instead of one TROUT. Technology sure raises hell with us all."

A letter from **Paul Cushman** of Oklahoma City dealt largely with things connected with the Boston Mechanic Arts High School. Paul and I are the only ones left of the sixteen M.A.H.S. men who entered Tech with us. He asked me for the first name and present whereabouts of one of the boys we knew there. As we get older we like to think about long past events. If there is any member of our class whose address you would like, write to me and at the same time tell me something about yourself.—**Oberlin S. Clark**, Secretary, 50 Leonard Rd., North Weymouth, Mass.

12

A card received from **Wallace Murray** in September gave news about his current annual trip, which this year was to Siberia. He has previously visited the Arctic and Antarctic. From Moscow he flew to Uzbecistan where he visited several nearby cities, then on to Erkutskin in Siberia and south to Ulen Bator in Mongolia where he visited several more cities. These are unusually modern. He then went into eastern Siberia and to the Pacific Ocean, returning via Japan and Alaska, and included many other out of the way places. Our congratulations to you Wally, on your unusual stamina.

Mac MacCormack sent me a long and interesting letter regarding a summer trip with his daughter to his native New Brunswick, where he visited his old home in Somerville, his high school in Woodstock as well as the campus in Fredericton of the University of New Brunswick, his alma mater. During the trip he found a few friends still living with whom he visited. Mac also sent me a large post card of the Hartland covered bridge, the longest in the world, which is located near where he grew up.

Ken Robinson, who recently moved to California, has changed his address in Concord to 1726 Live Oak Ave. . . . **Walter Slade** has moved from his life-time residence in Providence, R.I. to 2783 West Shore Rd., Warwick, R.I. where he is taking things easy. . . . I talked by phone with **Jesse Hakes** in Glenwood, Md., who had recently returned home after two prostate operations. We are most pleased to advise that Jesse is staging a remarkable recovery. He has, however, a problem as to whether he should continue to operate his large nursery. . . . **Jim Cook** writes that he is feeling fine. He recently luncheoned at the home of **Fritz Shepard** and Betty. Fritz's arthritis is continuing to give him trouble and he again had a check-up at the hospital. Our best wishes, Fritz. Jim also reported that **Harold Brackett** and his niece, Eleanor Forbes, had visited **Larry Cummings** and Julie as usual last summer at Squam Lake, N.H., but very heavy rains prevented successful fishing the last few days of their stay. . . . **Billy Reeves** of Palmerton, Pa., writes that he and Bea drove out to Minneapolis in September to attend the wedding of his grandson. They returned via northern New York State for a short visit with Bea's sister. . . . I received word from his wife, Betty, that **Howard Cather** of Rochester, N.Y. died suddenly of a massive brain hemorrhage on July 1, following a slight stroke he had suffered last January. Howard spent most of his career with Eastern Kodak Co., and was an inveterate bridge player. He had for many years spent each winter with friends in Florida where he enjoyed the fishing. He was one of our most interested alumni, keeping us posted frequently of his activities. We shall miss receiving his many contributions. . . . **George Robinson** of Silver Spring, Md., who lost his wife in 1969, sent a brief note saying that he is in reasonably good health. . . . **Ora Merry** has recently moved to 810 Thornton St., Minneapolis, Mn. 55414. . . . **Ken Barnard** of Barnstable, Mass., says he has finally retired from his work as consultant with Colonial Candle Co. He celebrated with his wife, their sixtieth anniversary last June in the same church in which they were married. Both are in reasonably good health. . . . A note from **H. C. Dunbar** says that they are enjoying their new location in Damascus, Va., which has much less traffic than Miami where they spent nine winters.

I have just returned (in October) from a covered bridge trip to western Pennsylvania with my daughter and son-in-law, where we visited 35 bridges, one in West Virginia. This is wild and very hilly country, with many small villages, and this fall the foliage was particularly beautiful. There is practically no manufacturing in Washington and Greene counties, which have steep and narrow roads, many sheep and cattle farms and also individual oil wells and allegedly many "moonshiners".—**Ray E. Wilson**, Secretary, 304 Park Ave., Swarthmore, Pa. 19081

13

The Holiday Season is nearing and we wish you all a Merry Christmas and a Happy New Year. We are indebted to the Alumni Fund Office for several items of news, "Health has permitted me to continue my engineering work. I am now 84. Registered in California and Nevada. Have wonderful wife, (55 years married), two sons, five grandchildren, five great grandchildren. All appear to like us. **Charles A. Smith.**"

We have received a number of letters from the 60th Reunion members, "Thanks for your nice letter regarding your well earned awards. Enclosed are a few highlight shots of our 60th. Keep well and our best wishes to you both. Beulah & **Bob Tullar.**" Thank you Bob, for the highlight shots. . . . "Hi. The class picture, identification page, and list of classmates have just arrived. You have done a beautiful job, but don't see how you did it so quickly. We think the picture is especially good and expect to enjoy it indefinitely. We are very happy that we were there. Best wishes for a happy summer to you both. Eva and **Fred Lane**". Thank you, Fred. We have credited your dues account for seven and one-half years. . . . "Thank you indeed for sending the group picture and other mementoes out to **Paul Cogan** to show him and Arlyle, and to give them an account of the Reunion. Paul has been out of the hospital about two weeks after his heart attack. He looks very well and seemed like his old self, but he must take it very easy. They were very pleased to see the picture and the lists of members. The weekend after our 60th, I went to the 62nd Reunion of my Class at Princeton; for the past three years I have been Chairman of the Reunion Committee. Though not so elaborate, we again had a fine time and good weather. We had only ten members present, plus a number of wives, daughters, and widows of former class members. We had 22 members present at our 60th two years ago. **Gene MacDonald**, by the way, lives only six miles from Princeton. . . . And I was surprised to learn that **Fred Kennedy** lives only 20 miles from my son in California. Also Mrs. Beulah Tullar lives in Lansdowne, Pa., where my son-in-law was born and brought up. She knows Dick's mother very well and plays bridge with her frequently. . . . Small world etc. **Allison Butts.**" Allison, the Class of 1913 is very proud of you and we congratulate you for your accomplishments and the well deserved awards which have been bestowed upon you. Allison Butts, a 36-year member of the American Society for Metals, Lehigh Valley Chapter, has been elected a Fellow of the American Society for Metals. Butts is Professor Emeritus of Metallurgy and Materials Science at Lehigh University. Professor Butts will be one of 52 of the Society's 40,000 members to be honored at a convocation of fellows at the Society's 1973 Metal Show and Materials Engineering Congress in Chicago, October 1 to 4. Professor Butts joined the Lehigh faculty in 1916 and retired in 1957. He rose through the various academic grades at the university and was head of the Department of Metallurgy from 1952 to 1956. A native of Poughkeepsie, N.Y., he was graduated from Princeton University in 1911 and M.I.T. in 1913. Professor Butts was Chairman of the Lehigh Valley Section of A.I.M.E. In 1932. In 1955, he received the Bradley Stoughton Award of the Lehigh Valley Chapter of the American Society for Metals, and in 1959 Professor Butts was the recipient of the Mineral Industry Education Award of the American Institute of Mining, Metallurgical and Petroleum Engineers. After retirement from teaching on June 30, 1957, he went to Turkey in the service of U.N.E.S.C.O. to organize research in the Institute of Materials and Processing at the Technical University of Istanbul, returning at the end of that year. In 1967 he was elected a member of the Legion of Honor of the A.I.M.E. . . . To **Paul Cogan**, it was most gratifying to receive your letter and the newspaper clipping regarding Allison Butts. From Paul comes this note, "I am feeling fine again and am sorry to have missed the 60th Reunion, but am looking forward to the 65th. Bob Tullar and Allison Butts gave me a personal report of the 60th Reunion activities. I have nothing startling to report about my own activities. . ."

We were very much pleased to receive a letter from our new President **Henry Glidden** and his charming wife, Jane and we quote, "The idea of recognizing the long term dedication of **Charlie Thompson** and **Bill Mattson** to the Class of 1913 by making a contribution in each of their names toward an M.I.T. scholarship, as described by you over the phone, seemed an excellent idea. I thoroughly approve. Am enclosing a print from one of my Reunion slides showing you two, the **Pierces** and Janie and **Fred Kennedy.** Janie's ankle is still very bothersome but I'm sure there is some progress. We expect to be at Bryant's Pond about the middle of August and hope to get to Port Clyde as well, so we may pop in on you on the way south." . . . Also a newspaper clipping from the *Brockton Enterprise*, "Jane and **Henry Glidden** enjoyed the four day 60th Reunion recently, of his Class of 1913 at M.I.T. They stayed at McCormick Hall, one of the new dormitories for girls on the Cambridge campus. All the Cambridge buildings were built after the Class of 1913 graduated. The old M.I.T. buildings in Copley Square have been torn down. Although the old alumni enjoy the new campus, they often call up a memory of the old. At a short meeting following the class dinner, letters from some of those unable to come to the Reunion were read and then Henry Glidden was elected President of the Class. After the meeting, he showed color slides of the four previous reunions and of the Cabot Trail on Cape Breton, Nova Scotia. With all festivities over, it was back to Abington with a classmate from California, Fred Kennedy, for two days of reliving the past, and climbing the mountains of New Hampshire."

Allen Brewer again gives us interesting news, "Thanks for the picture and list of addresses which awaited us when we finally got home June 30. A dignified looking gathering. I'll file this photo with the former ones of past reunions. Our trip back via Yorktown Hgts., N.Y., and Fitchburg, Mass., was without incident. No gasoline troubles, though on Long Island they limited customers to $2. worth. There I had an interesting and productive meeting with the publisher of my new book, "Effective Lubrication." Its due for issue later this year. I'll keep you advised as to advance publicity." . . . **Charlotte Sage** always gives us regularly interesting news of her busy life, "What a wonderful surprise. No sooner written you than an envelope appeared containing a photograph, names, list of members, and addresses. Don't you think the picture is unusually good? I do, and am delighted to have it. Came up yesterday in my new Scout, plus three comic dogs, a boxer, dachshund, and corgi. All elderly and me to match, but we made it, happily. Here for the summer and I am sure I won't get to Maine, so I'll send my thanks and wish you the best." . . . We hear frequently from Ellen and **Bill Brewster** either by short notes or telephone. We are very happy to report that Bill is again enjoying good health and life in general. By the way, he was 81 years old on July 18, 1973. We had hoped that Ellen and Bill would visit us this fall. . . . We were pleased to receive a letter from our classmate, **F. Javier de Varona** of Cisneros 157-Camaguey, Cuba, and we quote, "Just a few lines to let you know I received your nice letter letting me know all the tentative plans for the 60th Reunion. I regret to tell you that I am not able to attend or send any contribution as is my desire, because the government doesn't permit us to send anything. I expect in the future to attend and I am very grateful to you."

It was most pleasant to have Jane and **Jack Farwell** visit us several times around August 11 while they were in Maine.

We have received a news clipping from *The Manchester Union Leader* as follows: "**John H. Hession**, 85, President of Natgun Corp., died May 11, 1973. He was a native of Manchester, N.H. Mr. Hession had been in the pre-stressed concrete water and sewer tanks businesses for more than half a century. He founded Natgun Corp., in 1956 and had served as its President since then."

Again, we were shocked to hear from Mrs. Sarah S. Font of the death of our loyal classmate, **Manuel Font**, who has contributed actively over the years. "Thank you for your card in the name of the Class of 1913. I am sending you the details of my husband's life as written by himself, so that you may publish that which you think is fitting for the *Tech-*

nology Review. My husband died on June 11, 1973. Kindly send me a copy of the *Review* when you publish some of his accomplishments." We are including in our notes the highlights of Manuel's life. "Entered the Institute at Boylston Street when M.I.T. was Boston Tech, half a century ago, September 1908. 'Tempus fugit.' Initiated into Omicron Chapter of Phi Sigma Kappa, October 17, 1908. My roommates at the Fraternity House on 16 Exeter St. were philosophic **Gene MacDonald** and romantic **Bob Nichols**. Just barely pulled through Course XI in June 1913. After travelling extensively through Europe, I returned to Puerto Rico. My first job was as Assistant Sanitary Engineer with the Dept. of Health. After two years at this I joined the U.S. Army on October 22, 1915 as a 2nd Lieutenant. During World War I, I was stationed on the Panama Canal. In May 1923, back to civilian life. City Engineer for the city of San Juan, Puerto Rico. Several assignments followed; Superintendent of Public Buildings, Assistant Chief Engineer, Puerto Rico Irrigation Service. Back to M.I.T. in 1927 for advanced work on structures under Professor Spofford, and electrical engineering under Professor Hudson. Returned to Puerto Rico in 1928 as Resident Engineer at Guineo Dam, a rock fill dam. From here my roving spirit took me to Peru, South America in 1929 as Resident Engineer at the Callao Port Works, for Frederick Snare Corp., of New York. Back to Puerto Rico in 1931 to take charge of the reconstruction of the Ponce Port Works. Then followed a series of other assignments; Electrical Engineer for the Public Service Commission, Chief Engineer of the Engineering Division of the Puerto Rico Reconstruction Administration, Manager of Puerto Rico Cement Corp. While on this assignment, I was called back to active military duty on December 22, 1941. During this period of military service I was attached to the G-3 Section of the General Staff for Plans and Training. Travelled to British Guiana, Trinidad, Cuba, Jamaica and the Lesser Antilles. The rest of the war years were spent as a "desk officer". Was discharged as Colonel, A.U.S. In 1948 I was retired as Colonel, A.U.S., and placed on the army's payroll. On my release from military service, I ran for the position of Resident Commissioner for Puerto Rico in Washington and was defeated. Decided to quit politics. Then followed a period of service with the Veterans Administration. On my release from the Veterans Administration I was appointed Technical Director of the Mayaguez Municipal Housing Authority. While with the Authority I was sent by the Pan American Union, Washington, D.C., on a low cost housing mission to the Republic of Ecuador. After serving four years in this position I took a trip to Egypt, Jerusalem, Turkey, Greece, Italy, France, Switzerland and Spain. I have taken part in civil and military activities. Department Commander, Department of the American Legion in Puerto Rico for five years, and two years President of the Reserve Officers Assoc. I have been State Commander of the Military Order of the World Wars. I have been a member of the Rotary and Optimistic Clubs and am a Life Member of the American Society of Civil Engineers and of the American Institute of Electrical Engineers." . . . The welcome sign at the Capen home is always out.—**George Philip Capen**, Secretary and Treasurer; **Rosalind R. Capen**, Assistant Secretary, Granite Point Rd., Biddeford, Maine 04005

14

Louis Charm wrote me a fine letter in September in response to my recent urgent appeal for news from classmates. As mentioned briefly in the March/April news, he's living in the planned city of Reston, Va., in an apartment in Fellowship House, only a short walk from a shopping center, another residential area and a lake. On Saturdays an open-air market with hundreds of stands suddenly appears, displaying a most varied conglomeration of merchandise from garden products to jewelry, making a bustling beehive of commerce where everybody is carefree and humanity is at its best. Because Louis' wife is in a nursing home, he lives alone and manages well with an occasional assist from his daughter. He adds that Fellowship House is a community of about 275 people with a 4:1 ratio of Female Liberationists to Male Chauvinists with the survival of the fittest. It has a capable and dedicated manager and many activities. Louis finds nearby Washington a beautiful and most interesting city in which a person can spend months browsing around. He goes occasionally with his daughter and friends to the art galleries and to the Smithsonian and last spring joined the M.I.T. Club, though he hasn't been able to attend many of its meetings.

At the 110th meeting of the National Academy of Sciences last April, **Don Douglas** received an award "for outstanding contributions to aeronautical engineering". . . . **Jim Reber** wrote in September that he and Aminda would be living in their home in Auburn, N.Y., until early October, when they would return to Houston. He went on to say, "We are both well and active. I was fortunate enough to win another very nice prize, for my age group 75 and over, in the annual tournament of the New York State Senior Golf. This was held July 12 and 13 at the Oak Hill Country Club, Rochester. I hope that we will be seeing you next June at our 65th Reunion."

The text of the 1973-1974 catalog of the San Antonio Art Institute begins with a letter to its patrons and friends from **Alden Waitt** as Chairman of the Board of Trustees. The catalog also lists him as President and Chairman of the Executive Board, and as Director of the Faculty.

The high spot of a short trip to Hawaii that Lois and I, our daughter, and Lois' sister took in August was a marvelous Chinese dinner given us by **Long Lau** at a fine restaurant in Honolulu. Long brought seven members of his family to join us at a big round table laden with the most delicious food imaginable. Long was with us in all four years and graduated with us in Course III. His career was naturally in mining engineering, first in Cuba for a year or two and after that in China. He has been living in Honolulu since about 1960 and has a son there.

Arthur W. Johnson died at his summer home in Wolfeboro, N.H., on July 26, at the age of 80. He was with us in all our undergraduate years and received his degree in Course II. His winter home was in Boca Raton, Fla. Arthur's first years after graduation were spent in engineering positions with several companies in the New York City, Buffalo and Boston areas. In 1930 he joined the State Mutual Life Insurance Co., in Worcester as a purchasing agent, and retired in 1956 as Vice President and Secretary. Arthur was a member of the Congregational Church in Wolfeboro and of the Morning Star Lodge of Masons. He had been an incorporator and treasurer of Hahemann Hospital in Worcester, a member of the Worcester Off-Street Parking Commission, a director of the Worcester County Safety Council, and a trustee of Chestnut Street Church. He was as well, a member of the Travelers Aid Society, the Kiwanis Club and Economics Club. Arthur leaves his widow, the former Edna F. Corney; two daughters, Mrs. Dorothy F. Mann of Hingham and Mrs. Barbara Anderson of Worcester; a brother, Harold P. Johnson of Kennebunk, Me., and seven grandchildren.

New addresses: **Hou Kun Chow**, No. 3 Humbert St., Flat C, 5th Floor, Mei Foo Sun Chuen, Lai Chi Kok, Kowloon, Hong Kong; Prof. **Walter C. Eberhard**, M.I.T. Room 3-459, Cambridge, Mass. 02139.—**Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

16

Speaking of reunions, more particularly of the 57th that we had in June at Chatham Bars Inn in Chatham, Cape Cod, some of us who were not able to get there have heard things that were not reported in the formal records. We hear for example that this year, after filling up at the shore dinner on the water's edge, and after trying to stand quiet for the taking of the class picture, nearly all the boys went to their rooms for naps! How about that! It surely doesn't sound like what happened years ago at Fisher's Island or even at the 50th just seven years ago in Osterville. Word came through, too, that **Paul Duff** was receiving congratulations for he had just had his 50th Reunion at Harvard Medical School. And we ourselves felt almost there, as we had a telephone call from our President, **Ralph Fletcher**, supplemented by multiple enthusiastic voices of many of those listed in the report of our faithful Assistant Secretary, **Len Stone**, in the last issue of the *Review*. And cards from several included a note from **Don Webster** indicating that "the old boys are slowing down but still show spirit". . . . Having mentioned Paul Duff, we still remember very clearly the little story he told at one of the fairly recent reunions about the agreement Frances and he made shortly after they were married, some 34-plus grandchildren ago. They decided that he should make all the big decisions and that she should make all the little ones. And then Paul commented that he had

not had to make any decisions yet! . . . **Elizabeth Pattee** of Hightstown, N.J., missed the reunion this year because of a delay until the end of June in getting off to her place near Small Point, Me. . . . Mil and **Charlie Reed** also missed due to a like delay in going up to their cottage on Androscoggin Lake, Wayne, Me. . . . **Rudi Gruber** reports his return in July from a month in Europe where he celebrated his 82nd birthday with his brother in Germany.

We have word that the eighth annual Joseph Warren Barker Fellowship in Engineering will be offered for a nominal one-year period beginning July 1, 1974 by Research Corporation, a foundation for the advancement of science and technology, of which **Joe Barker** was President and Chairman from 1945 to 1959. The Fellowship carries a stipend of $6,000 and a contribution of $2,000 for the use of the department in which the Fellow is enrolled. . . . Dolly and **Len Stone** had problems in early July on their Little Beaver Island in Lake Winnipesaukee with the water level way above normal due to those heavy rains. Just before mid-July Len was able to say: "Water down three inches from 12 inches above the wharf and boat house, leaving nine inches to wade through to get off and on the island."

Mildred and **Art Shuey** were part of perhaps the biggest world-wide event of 1973. Art has sent us something really outstanding to post on our bulletin board at the reunion next June—well-illustrated clippings from the July 20 and 27 issues of *The Shreveport* (Louisiana) *Journal* about the trip of the *Canberra,* the 5th largest cruising ship in the world, to the west coast of Africa to view the total eclipse of the sun on June 30. They were among the 1900 distinguished guests and scientists on the historic cruise, and one of the illustrations shows them chatting with astronaut Neil Armstrong, who was also a passenger. As noted by The *Journal:* "People who are turned on by the prospect of seeing the sun turned off had a thrill of a lifetime on June 30 when, from the decks of the cruise ship *Canberra,* they saw one of the longest solar eclipses since 699 A.D." From 200 miles off the coast of Africa it lasted over six minutes and it'll be 2017 before there'll be another like it. "The Canberra was one of two ships employing all available resources to assure optimum viewing conditions, and amateur astronomers vied with the experts who hoped to learn a great deal from this long eclipse. Actually the ship was a floating university, with courses offered by some of the top astronomical and scientific 'brains' in the country. College credits were given." Says Art, "The eclipse was wonderful, four times as long as the one we saw last year off the coast of Nova Scotia." Also mentions Art, "We spent several days with Sylvia and **Vertrees Young** just before he flew to Hartford for his Doctor of Science (Honorary) degree.".

We have word from **Phil Baker** as well as Gyps and **Cy Guething** in Michigan. On the telephone Phil sounded real sharp and is doing very well. Cy says their stay in Leland on Lake Michigan, the so-called cherry center of the world (except for **Chet Richardson**'s place in upper New York), gave them a real "rest from resting" and prepared him for returning home to harvest his fine crops of beans and tomatoes. Cy always, or almost always, winds up his sparkling messages with the advice "Keep breathin'!" . . . **Fred Upton** of Lanham, Md., reports that they are doing all right but that sometimes they have to go to the shop for repairs—the last visit for new parts (teeth). . . . **Charlie Lawrance** sends in an article from an August issue of the *Brockton Daily Enterprise* which "suggests how close we all live to history." It is quite a story about Dorothy and **Dave Patten**'s home at Goose Point, Duxbury—the Standish House built by Alexander Standish, son of Myles Standish. One picture shows "Mrs. David Patten seated by the front entrance, which was originally the rear, of her Duxbury home with its original granite slab "stoop" and the date 1666 on the chimney." A second picture shows Dorothy in the living room which "contains the original pumpkin pine panelling with its hand-wrought door latches and original fireplace built by Alexander Standish." We'll have the article for display on the bulletin board at the June reunion.

We are sorry to report the death on July 24 of **Charles Wareham** who was a member of the M.I.T. teaching staff for 41 years. He joined the staff in 1917 as a teaching assistant in drawing and design geometry and became an instructor in the chemistry department two years later. He was promoted to Associate Professor in 1941 and retired in 1957. Survivors include a son and a daughter, both of Marblehead, a brother, four grandchildren, and two great grandchildren.

And we are indeed sorry to report that **Frank Hastie** died on August 14 after a heart attack in the Calvert County Hospital. He was a retired army Colonel and lived in Dowell, Md. As indicated in the *Washington Star News:* "Commissioned a Second Lieutenant in the army in 1917, Colonel Hastie later accompanied a class of West Point graduates as an engineering instructor on a year's tour of French battlefields. During World War II, he served in the Canal Zone and made inspection tours with the Corps of Engineers in the Pacific. He retired from the army in 1945. "Services were held at the Ft. Myer Chapel with burial in Arlington National Cemetery. He leaves his wife, Amelie, three sons, a daughter and 11 grandchildren. Besides having word of Frank's passing from Amelie, letters came from **Fred Upton** and from **Joel Connolly** of Tucson, Ariz., who says that he had just sent the Hasties an anniversary card. Frank had been one of our most active correspondents over the past two years—his witticisms and good clean fun will be sorely missed. We all send our deepest sympathy to Amelie and the family.

We also regret very much to report the death of **Charlie Cellarius** in Yugoslavia on September 8, as he was beginning a tour of the Balkans with his sister and friends from Cincinnati. He was one of the foremost architects of Cincinnati and was known as an authority on Colonial design. Following his early work on many of the finest residences in Cincinnati, he was the architect of many college and university buildings for Berea College, Ohio University, Ohio State University, The College of Wooster, Western College for Women and Miami University. He designed more than 50 buildings for Miami University, all of a Colonial character that has given Miami one of the most consistent and beautiful campuses in the country. After becoming senior partner of a firm with H. F. Hilmer, the firm designed the Union Central Life Insurance Co. building and several Presbyterian and other churches, many in Ohio. He leaves a sister, a daughter and five nieces and nephews. He will be particularly missed as one of our most enthusiastic reunion photographers.

We have word from **Paul Austin**, **Merrick Monroe**, **Francis Stern**, **John Fairfield** and **Joel Connolly** which we'll hold over for the next issue. It all helps if you write just a little but write often to your two collectors of news and chunks of seasoned philosophy.—**Harold F. Dodge**, Secretary, 96 Briarcliff Rd., Mountain Lakes, N.J. 07046; **Leonard Stone**, Assistant Secretary, 34-16 85th St., Jackson Heights, N.Y. 11372

17

By common consent our 56th Reunion at Northfield was one of our best, some said "the best". There was a good attendance of 36 including three of our honorary members and two widows. We were privileged and pleased to have Jay Stratton and Phyl and Don Severance with us for the full time and also Betty (Mrs. Phil) Hulburd and Dorothy (Mrs. **Ralph**) **Ross** and her daughter.

The weather and the foliage combined for our pleasure. The Northfield Mountain Pumped Storage Project, now in full operation, was of particular interest especially to those who had witnessed its progress from three years ago. Our group appreciated the privacy afforded by the Inn. Three stalwarts played golf; **Stevens**, **Ken Lane** and **Maher**, while others visited shops and points of interest. Helen and **Frank Butterworth**, at the piano, enlivened our social hours and this time there was a bit of dancing. Wednesday evening **Stan Lane** treated us to a South American travelog which he finished with movies and then slides of other reunions including our 55th at Chatham Bars Inn. A highlight was the professional piano recital by Susan Williams Lunn given Thursday afternoon. This was a real treat.

President **Lunn** presided over a business meeting Thursday evening. Treasurer **Lane** reported enough of a bank balance so no dues appeal was necessary at this time. **Bill Hunter**'s appointment as a Class Agent to succeed **Ray Brooks** was confirmed. Al Lunn reported that the 1917 Aldin Scholarship Fund had gone over the top and that it, with the 1917 Memorial Fund, produces about $10,000 a year for scholarships. He also reported that the red blazer presented to Arthur Fiedler, conductor of the Boston Pops, by the Class of 1922, which he uses frequently, is showing signs of wear. To take care of this the meeting voted to

give conductor Fiedler a 1917 red blazer next June as he says he would have been a 1917 member had he attended M.I.T.

There was a unanimous vote to return to the Inn next year for our 57th. President Lunn's suggestion that the Class might wish to have new officers was turned down noisily. President Lunn asked M.I.T. President Emeritus Jay Stratton to say a few words. We were fascinated by his reminiscent anecdotes beginning with his early Seattle days with his "wireless", and appreciated his taking time out of his busy schedule to be with us.

After our group breakfast Friday we departed in anticipation of next year. Those attending were: the **Butterworths**, **Dud Bells**, **Cristals**, **Dennens**, **Dunhams**, **Dunnings**, **Holtons**, **Hunters**, **Ken Lanes**, **Stan Lanes**, **Lunns**, Severances, **Ray Stevenses**, **A. P. Sullivans**, **Wilsons**, Betty Hulburd, **Phil Maher**, **Jess Rogers**, Jay Stratton and Dorothy Ross.

Nothing pleases a Class Secretary more than responses from and news of classmates. The cards returned because of our recent reunion letter were over 50 per cent of the mailing which is a significant showing. Be assured that it is appreciated. A good proportion bore messages. They cannot all be included this month but, happily, form a backlog for future notes along with a listing of names of those who replied which might inspire a thought or even a message. All widows of record were invited to the reunion and many responded with, "I am happy to be remembered."

Tom Ryan writes from Joplin, Mo.: "'Man bites dog'—Three old customers of sales agent Tom Ryan give surprise gift to Mr. and Mrs.—two weeks in Europe! Almost a believe it or not, Ripley. Leaving October 4, 1973." Congratulations, that makes Tom the salesman of the year. . . . **Walt Beadle** writes, "Sorry we can't be with you but we are in process of moving from our home in Wilmington to an apartment in a new retirement community, Kendall at Longwood, in Penn., only ten miles away." . . . Recently **Penn Brooks** was off to England, the **Al Ferrettis** were in Spain and the **Neubergs** in Europe. . . . Who will help **Stan Chisholm** out? He writes from San Diego, "I constantly look for news of Course V classmates in vain. Possibly they have little to report, the same as me. After 55 years I am a life member of the American Legion." . . . **Art Dickson** is "active and well, completing my year as President of the Standish (Maine) Kiwanis Club. Continue to be active in real estate and antiques."

The Leslie Fords "have gone rustic. We have sold our Weston, Mass. home and the summer place at Mattapoisett and acquired a place in East Marion, Mass. The house was built in 1715. Restoring and modernizing it and other buildings provide many problems. What with trying to get workmen, materials, things done the way we wish and finding money to pay for it all, we are having a good time for ourselves." The **Dunhams** and **Dunnings** spent an enjoyable day with Marion and Les and were fascinated by the old house and the terrific amount of work they are doing. . . . There are several classmates who have said more than once, "Don't keep putting my name in the notes." **Ray Brooks** was one of them. Just the same thanks have to be extended to him for his willing and careful years of work as Class Agent from which he now retires.

At a world meeting of the International Union for Health Education in Paris in July, **Clair Turner** (Professor, Ed.M., Dr. P.H.) was the first recipient of the Parisot Medal for distinguished service to health education. The first program of professional study in health education was established at M.I.T. in 1921 in a program directed by Professor Turner and approved by Professor Sedgwick just before his death. Several thousand professionally prepared health educators now serve the various countries of the world. . . . The Alumni Officers Conference (A.O.C.) held in Cambridge in September brought a record attendance. Our officers attending were **Lunn**, **Stan Lane**, **Ray Stevens**, **Dennen** and **Dunning**. Any doubters as to where and how M.I.T. is going would have come away enthused and excited about the Institute of today. . . . **Robert Mulliken**, Nobel Prize winner, spoke at Moraine Valley Community College, Palos Hills, Ill., last April on the topic "Evolution of the Universe."

With regret the deaths are recorded of **William L. Campion**, September 6 in Boston; **William B. Colleary**, August 18 in Centerville, Mass., and **Erasmus G. Senter Jr.**, August 22 in Dallas, Texas.

New addresses: **W. J. Littlefield**, 6816 Altamira St., Coral Gables, Fla. 33146; **Harry Fine**, 4027 Roberts Point Rd., Sarasota, Fla. 33581; **Walter J. Beadle**, Kendall at Longwood, Box 217, Kennett Square, Pa. 19348; **George D. Kittredge**, 2099-A Ronda Granada, Lagune Hills, Calif. 92653.—**Stanley C. Dunning**, Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard**, Assistant Secretary, 21 East 87th St., New York, N.Y. 10028

18

Your Secretary is most happy to record the fourth annual 1918 mini-reunion at Endicott House, Dedham, on October 21. This event was a most enjoyable one with a cementing of friendships of yore—interspersed with the feeling of togetherness as members of the M.I.T. family—all at a handsome estate with ideal fall weather. Never has the Class spirit been so high—as evidenced by the demand for a repeat performance next fall.

The 1918 attendees included Frances and **Pete Harrell**, Mildred and **Charlie Watt**, Dolly and **Eli Berman**, Helen and **John Kiley**, Dorothy and **Clarence Fuller**, Dorothy Rossman, Selma and **Max Seltzer**, **Sax Fletcher**, Stella and **Al Grossman**, Marie and **George Sackett**, Marion and **Herb McNary**, Elizabeth and **Julie Howe**, Gladys and **Len Levine**, Jean and **Mal Baber**, and Elinor and **John Kilduff**. Special Kudos go to the Harrells who came the greatest distance from Baltimore with runnerups being the Babers from Philadelphia. In addition 1917 guests included the **Brick Dunhams**, the **Al Lunns**, the **Bill Hunters**, and the **Stan Dunnings** while 1919 added to the festivities in the persons of the **Ben Bristols**, the **Jim Holts**, the **George Michelsons**, and **Roy Burbank**.

Saxton Fletcher, '18, right, owner of the Cloverly Farm in Greenfield, New Hampshire, is shown at an auction in October in which his famed herd of cattle was sold. Shown with him is Leon Young, who served as Herdsman for the past 32 years. The Fletcher herd is considered to be one of the most prominent in New England. Fletcher decided to auction his herd due to a lack of help and grain supply and sounded a bit sad as he spoke to those at the auction. Photo by David Dodge, courtesy of The Ledger.

The program started at noon with a sherry hour followed by a delicious luncheon. The speaker of the afternoon was Ken Wadleigh, M.I.T. Vice President. He described in an interesting fashion the growth of the Institute over the past 60 years—including a nostalgic dividend by way of pictures (courtesy of the archives of the M.I.T. Libraries). The first slide showed the Cambridge campus in 1914—a barren waste, looking as though it had just been bombed. Then civilization started—order was created out of chaos—foundations and then superstructures appeared on the screen—the great court buildings came into being—soon we had to go in the air to see the scope and dimensions of the 1973 M.I.T. as it is today. A question and answer period followed which gave some ideas as to the growth of the Institute in so many directions. In particular the new health care plan for the 10,000 employees has great possibilities for application to all sectors of society. The day concluded with a cocktail hour and refreshments. Our thanks go to the Alumni office attendees, namely, the Dick Knights, the Ken Brocks, the Fred Lehmanns, and the Joe Martoris for their participation on this happy occasion.

Jean and **Julie Avery** sent their regrets at not being with us on October 21. They had unexpectedly been in Florida where Jean is recovering from virus. Incidentally, I am grateful to about 50 of you who were kind enough to return reservation cards even though regretfully you were unable for various reasons to be with us at Endicott House.

Tom Brosnahan's *All Over the World* has now been published and is on sale at book stores. I just finished reading it.

He mixes his keen observation of the places he has travelled with items of their history and geography in a most interesting fashion. The publisher is Vantage House. . . . Selma and I visited the **Sam Chamberlains** one afternoon in early October. Sam has made a good comeback from his serious operation of a year ago and is getting on well on a restricted program. He is writing another book.

We have a new address for Lawrence J. Allen, 522 Monte Vista, Glendale, Calif. 91202.—**Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard I. Levine**, Assistant Secretary, 519 Washington St., Brookline, Mass. 02146

19

Our Class Agent **Dean Webster** has written to the Class to plan and help in the 55th Reunion gift to the Alumni Fund and I am sure the Class will participate to the best of their ability.

Your Secretary had a fine letter from **Marshall Balfour** in September. Bal went to the Saratoga races to see Secretariat lose, spent 10 days in New England and a week at Rehoboth Beach, Del., with his children and grandchildren.

Morton Smith, 21 Brainard Ave., Gt. Barrington, Mass., sent word that he had just received word from Mrs. Adams notifying him of the death of our classmate, **Franklin Stanley Adams** on August 8 in Paducah, Ky., where they lived for some time. He had been hospitalized since May after a heart attack with other complications.

The Alumni Association informed us of the death of **John Meader** on August 1, 1973 in New York.

Your Secretary returned to Florida via the auto train early in October after four months in various parts of the world.—**E. R. Smoley**, Secretary, 50 East Rd., Delray Beach, Fla. 33444

20

A card from that indefatigable world traveller, **Harry Kahn**, discloses that this time he is in Kamena Vourla, Greece, 125 miles north of Athens. Harry is supervising the development of an ultra-modern tile plant. He uses his weekends to visit Corinth, Delphi and Thermopoli, "reliving high school history and geography," says Harry. This note mentions that **Sam Ruttenberg** died early this year. Sam was formerly President of Amperite Co., Union City, N.J.

This brings me the sad duty of reporting several deaths of prominent and valued classmates, among them, **John Crandon Nash**, a most popular and beloved member of the Class and its President during the junior year. Born in Cherryfield, Maine, but a long-time resident of Providence, R.I., John was President and Treasurer of International Moistening Co., and later founded the Nash Air Conditioning Co. He was well known throughout the world for his technical contributions to textile finishing machinery and pioneering development of thermo-plastic film. He held 28 patents in the U.S. and foreign patents in Italy, France, Canada, England, Germany and Japan. A prominent and active Mason, John was past President of the Squantum Association, a founding member of the Dunes Club, a member of the Hope Club, the Providence Art Club and the Society of the Cincinnati. He was an authority on Colonial furniture and antique glass. He is survived by his wife, Kay, to whom he was married for nearly 53 years, and by a son, two daughters and eight grandchildren. The Class has sustained a very great loss in the passing of Johnny. His memory will remain forever in our hearts.

Another widely known member of our class whose death last summer has to be reported with a heavy heart is **John M. Nalle** of Charlottesville, Va. John was at one time associated with the Institute's bureau of industrial cooperation and had retired to his home. He graduated from University of Virginia before joining our class. He and Frances came up to our 50th and at that time John looked as handsome and distinguished as always. We shall miss him sorely. . . . On the same day as John's passing the death of another valued classmate was reported, that of **C. Ellsworth Brown**. Long a resident of Kansas City, Ellsworth had retired and at the time of his death was living at Mt. Home, Ark. He was an engineer at Burns and McDonnell in Kansas City, a member of the A.S.M.E., and served in the navy in World War I and II. He leaves his wife, Harriet, a son, daughter and two grandchildren.

On a happier note, it is pleasing to report that **Mina** and **Perle Bugbee** are off on a trip to Switzerland and by ship down the Rhine, he, to attend the first European Fire Conference and to preside at one of the conference meetings devoted to the subject "Influencing Human Behavior for Fire Safety".

To all of you, your Secretary's warmest wishes for a happy, healthy New Year!—**Harold Bugbee**, 21 Everell Rd., Winchester, Mass. 01890

21

The 1973 Alumni Fund results have been mailed out to all alumni. The gifts of the Class of 1923 announced on Alumni Day still stagger the imagination but the annual report shows that 205 members of the Class of 1921 gave a total of $223,450 to M.I.T. during the past year—a gratifying amount. Credit goes to our two loyal Class Agents, **Edouard N. Dube** and **Edmund G. Farrand**, for their continuing efforts.

Your Secretary gets a side benefit from the Alumni Fund in the news items sent back on the Fund envelopes: **W. W. Brown** of Cleveland, Ohio, took a cruise around South America this past year, stopping at many ports on both coasts. . . . **Elmer Campbell** of Seminole, Fla., reports that he and his wife Becky took a 6000-mile bus trip around the United States in the fall of 1972, which included attending the national convention of veterans of both World Wars at Colorado Springs. The pace sounded exhausting, which must mean that Becky and Elmer are in good health. . . . **Carl Ellis** of Waltham, Mass., retired in 1971 and is living with his oldest daughter. . . . Colonel **Philip M. Johnson** of Portland, Me., writes that he and his wife attended the Olympic Games in Munich. "They were wunderbar!" Phil was awarded the French Legion of Honor in World War II for liberating Grenoble, France and capturing 1447 German mountain troops. This past summer he was in the process of buying a new boat to cruise around the bays along the Maine coast. . . . **Frederich F. Olson** of El Cerrito, Calif., bought a new house and is busy with remodeling and gardening projects. He and his wife travel east each year to visit family and friends in New England, and in addition have travelled extensively in Mexico, and to countries in the South Pacific. . . . **Harry Ramsay** of San Marcos, Calif., reports he is doing well after surgery for cataracts. His daughter was recently chosen "Homemaker of the Year" for Franklin County, Ohio in recognition of having four children of her own, and then adopting four more. . . . **John M. Sherman** of Waltham, Mass., continues to work as Curator of the Museum at the Grand Lodge of Masons, 186 Tremont St., Boston, Mass. . . . **George T. Welch** of Poughkeepsie, N.Y., spent the summer at their cottage on Lake Champlain near Basin Harbor, Vt. He and his wife are yet another couple who like to winter in Florida.

On their way north to their summer place in Brooklin, Me., Claudia and **Josh Crosby** stopped overnight with the Haywards in Ridgewood, N.J. Between a couple of hands of bridge, Josh related an anecdote that bears repeating. Shortly after leaving Boston on the Eastern Steamship Line for New York on a wintry night years ago, Josh went down to dinner. After giving his order, he looked around the dining salon and there on the other side of the boat sat **Manuel Vallarta** and Professor Norbert Wiener. Manuel looked up, saw Josh, and called across the room, "Crosby, hey Crosby". With everyone staring, Josh got himself and his order, moved, and a gay threesome continued dinner. Professor Wiener told about some of the tricks he played on his professors as an undergraduate at Tufts University. After dinner they took several turns around the deck, interrupted, Josh says, everytime they heard a vibrational sound, at which point they stopped and Manuel and Professor Wiener discussed the mathematical formula of the vibration. Manuel Vallarta is known today internationally as a top nuclear scientist in Mexico. Your Secretary remembers him as a lab assistant under Professor William Hall in the Analytical Chemistry lab.

Various classmates have taken pen in hand during the past summer and thereby made our job easier. . . . A card from Helen and **Bob Miller** told of a delightful trip around southern Ireland visiting many places of pleasant memory to your scribe. . . . Millie and **Herb Kaufmann** rented a cottage on Squam Lake, N.H. for the summer. . . . Theona and **Al Genaske** had a busy season running Theona's hotel, "Farringtons", on Kezar Lake, Me. Helen St. Laurent dropped in three times to see

the Genaskes and was inveigled into spending one day working on a difficult jig-saw puzzle. . . . **Glenn Fargo** wrote that he and his wife planned to take their eighth trip to Europe this fall. He didn't make the interim reunion at Bardmoore last March, sticking close to home awaiting arrival of their latest grandchild. . . . The **George Gokeys** have sold their home in Jamestown, N.Y., and plan to "investigate east coastal resorts and choose our Shangri-La." They continue to spend winters at St. Maarten. . . . The **Sam Lundens** were planning to leave their summer cottage on Cape Cod and take a trip to Quebec on the Viking ships during September. Their cottage on the Cape is on Follin's Pond in South Dennis. We have later word that they boarded the cruise ship mentioned, *Royal Viking Sky* in New York on her maiden voyage to Quebec. On board, Mr. Frederick J. Pohl lectured on the Vikings' sojourn on the Atlantic Coast about the year 1000. He had a map showing the site where Lief Erickson landed and built a Viking vessel. This site turned out to be located directly across Follin's Pond from the Lunden cottage.

Sam met a classmate aboard the cruise ship, **Alfred D. Reid** and Mrs. Reid of Pittsburgh. He is still practicing architecture. . . . **George Chutter** reported a brief call at their East Dennis home, of Kay and **Ed Delany**, now living in Naples, Fla.

A long and welcome letter from **Dugald Jackson, Jr.**, describes in detail how the traveling Jacksons, Dug and Betty, have been on the go since last Christmas. Visits to children and grandchildren in Mt. Dora, Fla., and Schenectady, N.Y.; family weddings and anniversaries; luncheon and dinner dates with the **John Alex Scotts** in Daytona Beach and the **Helier Rodriguezes** in Tampa; and lastly a ten-week visit to the British Isles. The last awoke many memories of the Hayward's trips to England and Ireland in 1966 and 1968—the narrow country roads, Roman walls and ruins, the hedgerows that interfere with the view when driving, Irish jaunting cars, Stonehenge, etc, etc. Hope you took lots of pictures, Dug—we'd like to see them.

The Alumni Officers Conference on September 15 was well attended by the Class of 1921. A two hour workshop session of Class Secretaries the afternoon before, produced many comments on *Technology Review* reader habits, editorial content, circulation, et. al. A varied program was presented on M.I.T.'s short and long range planning; a number of separate discussion groups covered admission policies, the financial problems, curriculum and allied subjects. Those attending from 1921 were Wallace Adams, Josh Crosby, Ed Dube, George Chutter, Sumner Hayward, Irving Jakobson, Emma and Al Lloyd, Ted Steffian, Joe Wenick, and Win and Royal Wood. News gleanings: **Josh Crosby** has been elected Secretary of the M.I.T. Club of Southwest Florida. **Joe Wenick** is writing letters to his town paper these days about their taxes and budgets. Strangely enough he thinks they are too high. **Wally Adams** planned to tour northern New England after the conference and visit Ocy and

Asher A. Cohen, '21

Al Breed. Al is President of the Humane Society in Laconia, N.H. Wally also reported that **Edwin R. Clark** is ill and in the Marblehead Hospital.

A letter from the Information Officer of the Small Business Administration tells of the continued dedication of **Asher Z. Cohen** in assisting small businesses in Maryland. "Colonel Cohen spends three, four and sometimes five days a week in sharing his experiences and expertise. He is currently serving his second term as Chairman of the Baltimore Chapter of SCORE. In March he was presented a special citation for continued outstanding voluntary service." Congratulations, Asher!

Last month we reported the passing of **Harry Field** after a long illness. A very warm letter from Catharine Field said in part, "Harry and I celebrated our 50th wedding anniversary last September (1972). They were indeed Golden Years. Although physically ill for several years Harry still enjoyed life and kept his alert mind and keen humor. A great many notes I am receiving speak of his sense of humor."

Your Secretaries wish you many joys over the holidays.—**Sumner Hayward,** Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary for Florida, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden**, Assistant Secretary for California, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

22

Christmas greetings go to all our classmates from the beautiful fall golfing paradise around Buffalo, N.Y. October is always our best month with Indian Summer rounding out a lovely year. Because of a business meeting in Portland, Ore., your Secretary will have an opportunity to call on Banff Springs, Vancouver and Seattle this fall with hopes of seeing Catharine and **Mac McCurdy**. Many of my Buffalo friends have reported meeting the **Abbott Johnsons** and the **Fran Kurtzs** on the North Cape Cruise this summer aboard the *M. S. Kungsholm.* We were glad to receive their greetings. . . . **Charles Maschal** of Laguna Hills, Calif., reports a pleasant and restful trip with his wife from a 70-day cruise to the Orient last Spring. . . . **Joseph M. Cosgrove** of Brookfield, Ill., has asked for a copy of our Fiftieth Reunion coverage during June of 1972. This was sent with a cordial invitation to join us next June.

The 1973 Alumni Fund record indicates that **Dale Spoor** and **Don Carpenter** are doing their usual fine job of appealing for gifts. Our Class has had a 51 percent participation by 260 donors. This is a great record after our Fifty Year Special Gift of 1972.

We are sorry to have lost several members of our Class and express sympathy to the families of **Charles J. Malloy**, Rumson, N.J.; **Edwin A. Gruppe**, Fayetteville, N.Y.; **Dexter N. Shaw**, Wayne, Penn.; **Norman N. Smith**, Boston, Mass.

Dexter Shaw was a prominent patent attorney and a native of Lowell, Mass. He was senior partner of Howson and Howson, Patent Lawyers and Chairman of the Board of Trustees of the Central Baptist Church. He was a Mason and a member of the Society of Mayflower Descendants. He was also a member of the Union League Club of Philadelphia and Saint Davids Golf Club.

Our sympathy also goes to the family of **James R. Maxwell, Jr.**, Ormond Beach, Fla. He retired from Standard Steel in Burnham, Penn., in 1965 and moved to Florida at that time.

The most recent address changes are: Joseph Greenblatt, Hollywood, Fla.; Dr. James L. Guardo, Brockton, Mass.; Francis J. Laverty, Boulder, Colo.; Dr. Edwin J. Purcell, Tucson, Ariz.; Russell F. Schreiber, Belen, New Mexico; Charles B. Schureman, Green Valley, Ill.; Lieutenant General Wilhelm D. Styer, Coronado, Calif.; Thomas M. Taylor, Naples, Fla.

For more and better class views, please send news.—**Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

23

Horatio L. Bond and **George A. Rowan**, Class Agent, represented our Class at the September Alumni Officers Conference. At the luncheon attended by some 400, William S. Edgerly '49, President of the Alumni Association, issued the 1973 awards to leading Alumni officers and organizations. One was a presidential citation to the Class of 1923. As a former class president and of the Alumni Association, "Bondy" received this award for the Class. The citation to the Class of 1923 reads, "Possessed of a unique spirit since its undergraduate days, the Class of 1923 has constantly been an example to others. Hundreds of its members have been officers, workers, and committee members in all phases of Alumni Association activities. The M.I.T. community has been enriched by the generous contributions—spiritual, intellectual and financial—of its members. We pay tribute to the outstanding accomplishments of the Class of 1923.

George W. Bricker writes "Just returned (May 28) from four months in Yugoslavia, coming back via Bulgaria, Greece, Hungary, Austria, Czechoslovakia and Denmark." . . . From **Jack Elfenbein** we learn that his Weight and C.G. Computer for aircraft has, after over eight years of battling with the U.S. Pat-

ent Office, been covered by broad patents. Previously reported in this column of the *Review* for March/April 1972, this computer weighs only three and one-half pounds and indicates directly in terms of gross weight and C.G. in per cent M.A.C. A boon to cargo carriers, these instruments have logged over 200,000 hours of flight experience without major problems on 20 DC-8F 63 aircraft. . . . From **Myrna S. Howe**, who graduated with us from Course VII, we have received belatedly (dated May 27 last) some very kind words of thanks for many messages received relative to her inability to attend our 50th Reunion. She goes on to say "The 100th anniversary for women—an event I should love to attend; and I so much appreciated the extension of hospitality for dormitory space. Maybe later they will permit me to sleep there a night or two. Happy reunions to all!" We are indeed delighted to hear from you, Myrna! Sorry about your health problems getting in the way of your attendance and hope that you are now recovered fully.

A short note from **Salvatore A. Guerrieri** tells us "Since my retirement in 1967, I've been actively engaged in development of processes and procedures for abating air pollution—especially in the fields of particulate removal, sulfur dioxide removal and sulfur recovery from products of combustion of fossil fuels." We are delighted to hear about this Sal—more power to you in this line of work in your post retirement years! . . . Now from **John S. Keenan** we learn ". . . was Vice President of Canadian General Co., at retirement late in 1965, after 43 years with them. Since retirement do management consulting during the spring and autumn months." He has a home in Toronto, a summer home in Penetang, Ontario and a winter home at New Smyrna Beach, Fla. . . . From **Bert McKittrick** we are advised, "Am in great shape—got my Social Security check last month so my friends now want me to play more gin with them." . . . **Scott Nicoll** says that he is "up to the ears in banjo and guitar picking and folk music. Most of the rest of the time is spent in keeping the small steamboats (including my 16-foot *Mikahala*) in running order here on San Francisco Bay."

On the recently sent out class ballot **Scott V. E. Taylor** writes, "Wishing you good health and longevity to our class officers. Am applying for a patent on an advanced type of hydraulic transmission. Also recovering from a third bout with an ulcer." Best wishes to all of you who refuse to retire in spite of the years and various ailments. Now we have quite a bit of info from our very good friend Albert J. Pyle. From the *Bridgton News* (Maine) we learn that Al, after a long and distinguished career in teaching physics, applied electricity and mechanics first at the college and later at the secondary school level, followed by responsible direction of Research and Development work with Ford Instrument Co., and finally Senior Publications Engineer for the Sperry Gyroscope Co., has now in his retirement (?) gone into the design and manufacture of fine jewelry. Two examples of this fine work were mentioned. The first is the manufacture of an engagement ring in gold for his present wife, the former Miriam LeMon of New York. This ring was a rendition of two hands, each clasping their individual birthstones. The second was the creation of matching wedding rings for his daughter, Cynthia and her fiance. Dr. Richard Stanley Kayne, this last September. These rings also of gold were made in the form of Moebius twists—a geometrical pattern in which the inner and outer surface become continuous surfaces. These creations were produced by original carving on wax patterns from which the requisite molds were created. Great work Al!

From **Ida B. Webster** we learn that she is still practicing her career as an architect in the firm of Weiss, Whelan, Edelbaum and Webster, her specialty being nursing homes, housing for the aged and public housing. **Philip S. Wilder** attended two fiftieth reunions this year, ours at M.I.T. and the other at Bowdoin College from which he graduated in 1923. . . . **Tom Rounds**, your Secretary reports that some 160 ballots have been received so far concerning the amendment to the class constitution to permit the election of two more vice presidents. The result which cannot as yet be reported will appear in the next issue of the Class Notes.

We now have the usual sad duty to report on necrology. In alphabetical order we learn of the death of **Norman T. Allen** of Woods Hole, Mass., in May of this year; **Girard Boyce** of E. Williston, N.Y., on December 14, 1972; **R. S. Coupland, Jr.**, of Metairie, La., on June 27, 1973; and **John H. Neher** of Princeton, N.J., in June of this year. Unfortunately we have no details concerning these classmates' passing. . . . From the sister of **E. Louis Greenblatt** we learn of the passing of "Lou" on July 21 after attending our 50th Reunion. His sister, Ida Golden, is purchasing a book for the M.I.T. Library in his memory. . . . **Percival S. Rice** of South Yarmouth, Mass., died on September 13, 1973. Formerly of Wellesley and Lexington, Mass., he retired from Tufts University in 1969 as Professor Emeritus. He was a member of Tau Beta Pi and a life long member of the American Society of Civil Engineers. He is survived by his wife, Marian Thresher Rice, and a sister, Mrs. Lillian Larson of Orleans, Mass.—**Thomas E. Rounds**, Secretary-Treasurer, 4 Deer Hill Drive, Danbury, Ct. 06810

24

Top priority in the Class doings is our 50th Reunion, of course, and our major concern is for the 50th Reunion Class Gift. **Ed Hanley**, the Chairman, called his first Committee meeting on September 14, at the Institute's Faculty Club. In attendance were **Ed Moll**, President; **Paul Cardinal**, Reunion Chairman; **Ray Lehrer**, Treasurer; **Frank Shaw**, Class Agent; **Russ Ambach**, Secretary; **Lank Harris** and **John Fitch**. Unable to be present were **George Tapley**, **Gordon Billard**, **Rock Hereford**, **Max Ilfeld**, **Tom Johnson**, **Al Roig**, **Nat Schooler**, **Marshall Waterman**, **Jim Pierce**, **Dave Meeker**, **Phil Bates**, **Nish Cornish** and **Hood Worthington**.

Previous contribution records were reviewed along with territory assignments designed to make sure that all members were given opportunities to do their part. Each of you may expect to hear from someone in some way, although a half century has passed. Professor Henry Jacoby briefed us on the rapid changes that have occurred since we set the target of an "Environmental Laboratory." It is now more appropriate to name it "The Energy Laboratory." Chief reason as stressed by President Wiesner, Institute officers and faculty at the concurrent Alumni Officers Conference was that interlocking technological and social issues are nowhere more important than in the "energy" crisis.

I am sorry to have to report the passing of **Thomas R. (Dick) Rhea** on September 16, 1973 in Lake Placid, N.Y. He enlisted in the U.S. Army in 1917, went overseas and returned to Tulane University for two years, transferred to M.I.T., earning his S.B. in electrical engineering. He immediately signed up with the General Electric Co., and followed a career in application engineering, mostly in steel and chemicals. During World War II he worked on the Manhattan Project and returned to G.E. in 1946, eventually becoming manager of the general engineering unit of the industrial engineering section. Dick was a licensed professional engineer in New York State and a long-time member of A.I.E.E. He was always active in civic, political and church affairs, continuing after retirement in June 1965.

Ellis Oliver Jones died June 17, 1973 as reported from the Alumni Fund office. His last known address was Santa Rosa, Calif. Ollie was graduated in civil engineering, but joined the Ethyl Corp., in 1932 and in 1949 was still with them. We have no record of the following years' activities, except that he retired in 1967. . . . I have a copy of a letter from **Tom Bartram** '21, Largo, Fla., advising of the death of **Dana R. Staples** in November 1972, probably in St. Petersburg, Fla. Staples received his S.M. in electrical engineering and went to Westinghouse for nine years. In 1934 he shifted to Baldwin Locomotive Works in Philadelphia and in 1949 became Manager of the Diesel Locomotive Engineering Department. He was active in the Technology Club of Philadelphia and the American Association of Railroads. A member of the Pennsylvania Board of Professional Engineers, he authored several papers on diesel locomotives. The Class regrets the loss of these members and extends condolences to their families.

Belatedly I find the Alumni Records notice of Professor **Samuel Shulits**' death in February 1973, at Villa Nova, Pa. This is a personal loss to me for Sam and I were Civils in the first hydro-electric option of Course I. He spoke fluent German and spent 1928-1929 at Technische Hochschule in Berlin. His career was basically hydraulics in various U.S. Government departments and teaching. In 1942, he received the rank of Major in the U.S. Army Engineers, becoming Deputy U.S. Chief, Transport Group, Bipartite Control Office in Frankfurt, Germany. Later, he

was a Visiting Professor of Hydraulic Engineering at Penn State, University of New Brunswick (Canada) and Villanova University. His research project, "Bedload Formulas," was so much in demand that it was re-issued and translated into German. My heartfelt sympathy is extended to daughter, Erica, and son, Walter.—**Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Ma. 02146

25

The best laid plans of mice and men are often changed and ours were. Unforeseen events caused postponement of our European trip but we hope that we can take it next spring. However as a result I was able to attend the Class Officers' Conference at M.I.T. and had a very interesting time. It was instructive to see and hear the various presentations and undoubtedly items that were covered will be published in the Technology Review. However it is impossible to present in cold print the enthusiasm that was shown for the present and future of M.I.T. It gave me a feeling that things are in good hands and that promising things are coming. I had an opportunity to talk with a number of students and they seemed to have a definite purpose and interest in the future. Our own **Carl Van Tassel** moderated one of the discussion sections.

At my request I received a very interesting letter from **Doc Foster** detailing all the honors showered upon him on his retirement from the Lowell Institute. First and foremost Doc wished to express his gratitude to all who participated. Sitting for a portrait was a most interesting experience. The artist was Robert Douglas Hunter and it involved 16 sittings of 3 hours each. The unveiling took place at the Annual Dinner of the Lowell Institute on June 1, 1973. The portrait was later displayed in the lobby of Kresge. In addition Doc received the Charles Francis Park Gold Medal which is the highest honor bestowed by the Alumni Association of the Lowell Institute. Now on his retirement on Cape Cod, Doc has many pleasant recollections and I am sure that we are all proud of our Class President. Now it is the time of the year that I want to wish all of you the best of the seasons greetings.

I am sorry to inform you of the passing of **Cornelius J. Enright** of Greenwich, Conn., on July 5, 1973 after a long illness.—**E. Willard (Will) Gardiner**, Secretary, 53 Foster St., Cambridge, Mass. 02138

26

It's a beautiful October day at Pigeon Cove and we do not look forward to trailing our sailboat home from the yacht club and tucking it away in the garage for the winter. However, the sailing season is over and we must.

Last weekend, the day of the disastrous Chelsea fire, it was blowing 40 to 45 m.p.h. and the only sailor to venture out was a 70-foot trimaran. It takes a gale to make them go and the owner wanted to test it (he bought it from a Frenchman after it placed third in the single-handed multihull race across the Atlantic.) You should have been here! The boat went through the water like a hydroplane, throwing a V of spray 50 feet wide and leaving an enormous wake.

As we have said before, the scenario at Pigeon Cove is unpredictable. One classmate who recently stopped by with his wife to catch a little of it was **Don Chase**. The Chases were on a fall tour of New England. They were headed for Maine and we suggested that they include The Old Tavern at Grafton, Vermont on their itinerary. A post card a few days later indicated that they had taken the suggestion and were real pleased with the Inn.

One classmate who really took to the road upon retiring is **Dwight Woods**. Dwight and his wife have been roaming with a trailer for four years but finally feel the need for partial settlement as he writes, "After being gypsies for four years after retirement, wandering around this country and several side trips into Mexico and Canada, we have decided to establish a home base here in Kerrville, Texas. During our 100,000 miles of travel we have always sought the ideal place to settle but have reached the conclusion that you have to accept a compromise. Kerrville was our choice for many reasons. The winters are mild and seldom when the sun is out is it below freezing. There is sufficient moisture to have trees and grass but the humidity is low during hot weather. Also, this is hill country so it cools off at night. Within two-days trailer travel we can change our climate and scenery drastically—the coast at Corpus Christi or Brownsville; the desert at Big Bend Park or Tucson; or the mountains in northeastern New Mexico or southern Colorado. A year ago we went through Vermont, New Hampshire and Maine before spending a month in Nova Scotia and saw **Charles Rich** in St. Albans, Vt. Dwight has built a small house on his newly acquired property with two-trailer parking spaces with full hook ups for his friends. So if you own a trailer you had better get in touch with Dwight and if you do not own a trailer you may now want to think about it.

In the spring we had some correspondence with **Austin Kelly** and during the summer he wrote us a P.S. to the last letter and we quote from it, "I forgot to tell you that Mary and **Mark Greer** came over to our home in Sharon, Conn., and spent the weekend with us. He is retired and looks younger than most of us."

At the meetings of the Corporation Development Committee we usually have a 1926 reunion since on this Committee are **Pete Doelger, George Edmonds, Jack Kimberly, Ted Mangelsdorf, Thornton Owen** and **Bill Sessions.**

A note from **Bob Ellis** tells us that he is still active as "Vice President of the Gibbane Building Co., and Manager of their New York office—minor travelling around the New York area, to the Republic of Ireland and to Central America. For vacation Helga and I usually go to Europe yearly. See Austin and Lee Kelly often, occasionally Alithe and **Cesar Canals.**"

And now for the unpleasant part of my job. A clipping tells of the recent passing of **Ralph Adams** of South Freeport, Maine and a note from Mrs. E. J. Bray tells us that classmate **Ed Bray** succumbed to a heart attack early this year. . . . In yesterday's mail I had a note from Margreth Richardson telling of **Bob Richardson**'s death on October 6. She mentioned that after Bob lost his sight a year ago she always read the Class Notes to him and it gave him much cheer to hear about the Class and Pigeon Cove. To the widows and families of these classmates your Secretary extends warm and sincere sympathy from the Class of 1926. . . . Now I see that I am writing December Notes so instead of my usual "cheerio", Ruth and I say "Greetings of the Season" to all who read these Notes and may 1974 bring you health, peace and happiness.—**George W. Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

Charlie Smith says there is still time to sign up for the trip to Greece in September, 1974 with a group of members of the Class of 1927. (Other alumni of M.I.T. are also invited to join.) "Fairly firm" commitments had already been received by Labor Day from Charlie and Ann Bartlett, Russ and Catherine Westerhoff, Larry and Lillian Grew, Bill Kaplan, Charlie and Eleanor Smith, Pub and Ruth Whittier, Fred and Ruth Willcutt, and Dr. James Southworth, and five other couples were tentatively thinking of joining. The trip will last 22 days, will cover Athens and other mainland sights, including Delphi and the Piraeus, Istanbul, and the Greek Islands, and will cost about $1190 per person. Write to Charlie Smith at his winter address, 138-D La Canada Rd., Green Valley, Ariz., 85614, or directly to World Wide Travel Agency, the tour organizer, at the Cincinnati Automobile Club, Cincinnati 45202.

Bob de Lucca is assisting in the reorganization of the Vietnam Power Co. He spent six months in Vietnam in 1971, and again in 1972, leading a team making a 15-year forward study of the economy, electric power needs, and money requirements year by year.

Charlie Sanborn writes that he heard on his "ham" radio that **Bill Felch** entered Englewood (N.J.) Hospital in October; he had no details. . . . **Bill Felch** is W2 A.E.S., and **"Steam" Harrison** also talks with Bill from time to time on ham radio. Steam made his annual trek back from Florida to Shrewsbury last spring, stopping in Jackson, Miss., on the way to visit his old Seabee skipper. He has spent the last six winters in Florida since retiring from Getty Oil.

Frank Connolly reports that all is well with him; he is living in San Clemente. . . . **Harold Edgerton** is in the news again; this time as part of a National Geographic Society expedition to search for the hull of the U.S.S. *Monitor*, which sank during the Civil War nine months after its historic battle with the Confederate ship Virginia (the former E. S. S. *Merrimac*). . . . **Fred Geary** has moved from Spring-

field, Mass., to Springfield Rd., Old Lyme, Conn.

Regretfully, we report that another member of our Class is gone: **Edward R. Vose**, who died on July 24 last. He had been retired for a number of years and was living in Lake Placid, Fla.—**Joseph H. Melhado**, Secretary, 24 Rodney Rd., Scarsdale, N.Y. 10583

28

Since the season is close at hand, may we wish each and all of you the happiest of holidays. We are still receiving favorable comments on the wonderful 45-year Reunion at Bald Peak Colony Club last June. . . . In a letter to **Jim Donovan**, **Roger Haven** says that he and Priscilla enjoyed every minute of that weekend. They are looking forward already to the 50th. The Havens are busy remodelling their home in Fryeburg, Maine with Roger doing most of the work himself. They report excellent progress. . . . **Paul Johnson**, also writing to Jim, expressed disappointment in having to miss the reunion. Dorothy had just completed her second cataract operation but was without her contact lenses at the time. Now she has 20-20 vision in both eyes and all is well. Their immediate plans were for a 21-day trip to Spain and Morocco, back to St. Louis, then off again to Aspen to attend the wedding of their youngest son, Randy. Shortly after the reunion **Ed Poitras** wrote to **Shikao Ikehara** in Japan and gave him a direct personal report on the event. Ed had visited with Shikao in Tokyo just a few weeks earlier. We all join Ed in the hope that Shikao can make it to the 50th.

The National Academy of Engineering announced the election of 70 members in May of this year. Included was **Henry A. Schade** of the College of Engineering, University of California at Berkeley, in recognition of his contributions to research, design, construction and performance of naval and merchant ships. . . . *The Progress* (Charlottesville, Va.) of July 1, 1973 carried a news item which tells us that **Jean M. Roberts** had been named Professor Emeritus by the Board of Visitors of the University of Virginia. Jean, a member of the engineering faculty of the University since 1952, retired on June 30 as Professor of Electrical Engineering. . . . A news item in the *Independent and Montgomery Transcript* (Collegeville, Pa.) of July 10, 1973 announces that Dr. **E. Vernon Lewis** is retiring as Professor of Mathematics and pre-medical student adviser at Ursinus College. Following graduation, Vernon earned his doctoral degree at M.I.T. then joined E. I. duPont deNemours and Co., Inc. in Wilmington, Del. Before going to Ursinus he taught at the University of Delaware from 1950 to 1964.

We have a most welcome note from Judith (Mrs. **Benjamin F.) Miller** who says it is always a pleasure for her to read the Class Notes. She enclosed the announcement of an exhibit of Ben's scientific papers, his books, poems and manuscripts to be held at the Free Library of Philadelphia, Central Library, Logan Square, November 5, 1973 to January 7, 1974. Three of Ben's books were published after his death in 1971. They are: *Family Book of Preventive Medicine, Freedom From Heart Attacks,* and *Encyclopedia and Dictionary of Medicine and Nursing*. The first two were published by Simon and Schuster and the last one by W. B. Saunders.

Bill Hurst, recently discussing the energy crisis, expressed his belief that the oil and gas reserves needed can be found domestically if petroleum engineers and geologists are given the assignment and if the government will establish a proper price structure. As you may know, Bill is a well-recognized authority in the field of petroleum engineering.

From Alumni Fund envelope panels we have the following notes: **Joe Collins** is still very much occupied with business but is beginning to think about retirement. He is associated with S.A.T.M.A., a subsidiary of Peckiney Ugine Kuhlman, a French company, and is consultant-agent for the U.S. and Canada. . . . **Arthur R. Smith** writes, "Retired as Vice President, Sales, City Auto Stamping Division, Sheller-Globe Corp., Toledo, Ohio on January 1, 1971. Will continue to live in Toledo near our two children and five grandchildren. I enjoy wonderful good health, golf and occasional travel." . . . From **George Hoffman** we have: "Retired in 1972. Now Executive Vice President of a new corporation installing and servicing standby engine and turbine generators to alleviate brownouts and to prevent blackouts in industry. Consultant in electrical plant surveys to improve efficiency with lowest capital investment. We have a new home in Naples, Fla., where the company will expand this winter in operations around Florida." . . . **Lazare Gelin** says, "Am now happily retired and trying to catch up on everything I have missed."

The Class President's letter that you all received in October initiated our effort toward the 50-year Class Gift to the Institute. As you know, all contributions to the Alumni Fund during the next five years count as a part of this gift. To date, Jim Donovan's Class Gift Committee includes: Homer Burnell, Roland Earle, Florence Jope, Tom Larson, George Palo, Dick Rubin, Walt Smith, Herm Swartz and Charlie Worthen.

With deep regret we must report that **Haskell C. Needle** died on October 7, 1973 following a period of illness. Haskell's professional work in the fields of biochemistry and food technology was widely recognized. He was listed in various volumes of prominent men, held responsible Research and Development positions during his career, and had a list of patents in his name. He had recently retired as Research Director of Presco Products, Inc., Flemington, N.J. We talked to his wife, Dorothy, and extended to her the sympathy of the Class.—**Walter J. Smith**, Secretary, 209 Waverly St., Arlington, Mass. 02174

29

Hyman J. Fine writes, "On June 30, 1973 (my birthday) I retired as Chief, Water Resources Planning Branch Norfolk District, Corps of Engineers. I shall continue to work on a temporary three-day basis for possibly another six months to a year. My wife, Edythe is also retiring from her administrative position with a shipping agency which handles foreign-flag vessels. My 44 years of work pertinent to the planning and development of water resources projects, dams, improvements of rivers for navigation, protection of beaches against erosion, have been interesting and stimulating. More recently, problems relating to properly insuring that the policies of the National Environmental Policy Act are met, and court cases stemming therefrom, wherein environmentalists strongly question some of the water resource developments, have created many problems. However, the professional water planner should take N.E.P.A., into account appropriately. Edythe and I will continue to live in our home in Norfolk, Va. I do thank you for sending me a birthday card from Class of 1929 which brings back many pleasant memories to me."

Everett F. Kelley writes, "Many thanks for your birthday card which came on Father's Day and our wedding anniversary. I have retired since June 1970 from I.T.T., in Lynn. I wasn't big enough to get involved in Watergate-type scandals but I do know some who are capable of that sort of thing. Since retirement, I work five to six hours a day doing chores around the house, landscaping, carpentry, painting etc., for myself and for some of our neighbors. We belong to two senior citizens groups which provide some fine programs. We took a trip to Bermuda last April and Washington, D.C., in May. Plan to go to Europe in October. During the summer all my family with their children came to visit us on the Cape. I see **Larry Harding** occasionally."

Mrs. **Elizabeth M. Stefani** writes, "Actually a great many 'petits riens'." My Victorian background was an ideal preparation for amusing myself and living alone. But having had four children and now six grandchildren and five brothers, I really find more to do than time to do it but couldn't while raising the children." . . . **Seymour A. Baum** is still at the helm as President of B.H. Aircraft Co., in New York. He and his wife, Claire are blessed with good health and play a lot of golf. He enjoys his work and has no thoughts of retirement as yet. . . . **Rolf A. Zurwell** is in business dealing with steel products and industrial design in Maryland. "Esther, my wife of 40 years, passed away several years ago, but I remarried late in 1972 to another fine Christian woman."

I regret to announce the deaths of two classmates, **Roger W. Tarbox**, of Malden, Mass., on December 5, 1972 and **Max I. Alimansky** of Pittsfield, Mass., on July 29, 1973. Max had retired in 1972 after 44 years with General Electric Co. He was Manager of Business and Technical Planning for the Power Distribution Division. He was also widely active in professional, alumni, religious and community affairs.

Received a post card from the globe-trotting **Hunter Rouse** and his wife Doi which reads, "Another hydraulics congress, another city! We have been in Karlsruhe (Germany—my second alma mater) since May; but it is almost time

to go back to work. I hope that the '29 column has been appearing as regularly as ever while we have been gone. Regards to all." . . . **Warren A. Spoffard** has retired (January 1973) after 43 years of service, from General Electric Co., as a design engineer dealing with the development and production of air conditioning equipment and related products. He and his wife Elizabeth have lived in Tyler, Texas since 1956 and they will continue living there in retirement. "We have just enjoyed an extensive tour of the Orient with Alumni Flights Abroad as advertised in the *Review*, and we were highly pleased with it."

Norman M. Wickstrand of Harwington, Conn., retired bearing engineer of the Torrington Co., recently submitted an article entitled, "The Fatigue Life of Drawn Cup Needle Roller Bearing" to a Tokyo manufacturer, Nippon Seiko Kabushiki Keisha which was translated into Japanese and published in a trade magazine there. Mr. Mas Ueno, the chief engineer of the firm presented Norman with a gift—an ancient replica of a Japanese-Chinese silk brocade as a token of appreciation. The article submitted for publication was original in scope. It details the active and passive patterns of roller bearings and their ability to withstand loads with a minimum of damage. Since his retirement, Norman has been teaching elementary mathematics at the Torrington branch of the University of Connecticut. He is also frequently called in by the Torrington Co., for consultation for various problems connected with the bearing industry.

George D. Rogers, Hot Springs National Park, Ark., has retired as an industrial engineer, specializing in explosives and manufacture of ammunitions. In 1938, he was in government service in "Military Occupational Specialty." In 1949, he was a Registered Professional Engineer in Washington, D.C. He retired from government service in 1954 and became a consulting industrial engineer in Arkansas. . . . **Joaquin J. Llanso** is Vice President and Manager of Knight Industries, Inc., of Broken Arrow, Okla., packagers of gas compressor units for the oil and gas industries. He also is in charge of international sales. . . . **Nathan E. Promisel**, Executive Director, National Materials Advisory Board, was granted Honorary Membership in American Society for Testing Materials. Honorary Membership is one of A.S.T.M.'s highest awards and is conferred upon persons of widely recognized eminence in this field. The citation reads, "Public servant, scientist, innovator; advisor and leader of his colleagues in government, industry and academia; initiator and promoter of international cooperative activities; for outstanding leadership in the field of materials and standardization."

William E. Lowery has just moved to a fine mobile home park in Plymouth, Mass. "As soon as we are really settled," he continues, "we will be able to take a trip and side trips on the spur of the moment without worrying about cares of a conventional house. Thanks for the birthday card, which will grace our living room for one full week."

I have a note from **Charles W. Denny** of Naples, Fla., announcing **Brig Allen**'s death which was reported in the last issue of the *Review*. "I attended a memorial service for Brig in Orlando on May 22. His health had not been good for several years, but what happened was quite unexpected. My wife and I have stopped to see him and Evelyn several times since we moved to Florida. Here is a little personal history. We sold our business in 1967 to Square D Co., and I became Vice President of the firm. In May 1970, I retired with a health problem, and in February 1971 we moved to Naples. In July, 1971, I had a spinal cord blockage which paralyzed me from the waist down. An operation was performed shortly thereafter to relieve the blockage and it took eight months for me to learn to walk again. I am OK now—can't play golf yet, but I have a boat and I do a lot of snook and tarpon fishing."

Kenneth W. Grimley writes, "It's disgusting! I've gotten so old and feeble that I have to cut the lawn sitting down, instead of standing up and pushing the mower as God intended. However, since I have three acres to keep partly mowed, and I have no yard man except my wife, whom I prefer to employ cooking supper, and considering the Alabama summer climate, perhaps I should not complain." . . . A letter from Florence Pierson sheds a little light on the sudden death of **Frank O. Pierson**, which was reported in the last issue of the **Review** as follows, "Frank's death was very unexpected and I believe needless. He tore a cartilege in his right knee and went into the hospital for a minor repair surgery. A pulmonary embolism developed which caused his death, not a heart attack as the doctor thought at first. Needless to say, this makes me feel worse, if that is possible. We did not go trailering last summer, partly because of the gasoline shortage and then because of his knee. Frank was planning so many wonderful trips in his retirement years, and was looking forward to attending his 45th Reunion next year. I am deeply sorry he is missing all that. Thank you for your letter and the information it contained concerning the widows' program."

Alexis B. Kononoff writes, "Have retired almost three years now. I thoroughly enjoyed the first three months, then I decided that the life of a retired person is rather dull and monotonous. Since there is nothing physically wrong with me, I decided to return to part-time consulting work." . . . **Murry Brimberg** has recently retired from his electronics consulting firm, Brimberg Associates, Inc., and continues doing occasional consulting work. He is planning to spend some time leisurely on the study of medical instrumentation, a field which has intrigued him for sometime, especially since his two daughters and their husbands are directly involved in clinical practice and research in medicine. "Since our last report" he continues, "our daughter has received her Board certification in Pediatrics, and the other is a faculty member at the University of Chicago in Hematology. The husbands, one is Chief of Medicine Michael Reese at the University of Chicago Medical School. The other husband is a Pediatrician doing genetic research in England. Mary and I just returned from a six-week trip abroad—our annual trek to London, Venice, Florence, Rome and Paris. We also spent some time at Monte Carlo. The reports of the many, 'sad but wiser' travelers are more true than fiction. The dollar isn't what it used to be. Inflation appears to have outstripped our own stiff prices at home."

Some of you have been asking in your notes "What is new with your Secretary?" Rather than answer individually, I would like to state briefly my activities, past and present. Like many of our classmates, due to the times, I was involved in many non-professional work and business ventures following graduation. For the past 15 years, I have been in my own field (Course XVII-Building Construction) Realty Development and Management (mostly building apartment houses and managing same). Profit margins from such operations have been steadily declining in recent years, due to high cost of land, materials, labor and finance. As a result, a few years ago, I stopped building and I assumed the job status of semi-retirement, which boils down to management of what real estate we own. This gives me plenty of time to enjoy life as a senior citizen. My wife Helen and I enjoy good health (aside from normal aches and pains associated with our age bracket) and we spend most of our time in our home in Hampton, N.H., and we spend winters in Florida. We have just one daughter, (married) and two lively grandchildren, aged 5 and 6, who give us so much pleasure. Recently, we took a trip for the first time to Athens, Greece, sponsored by the M.I.T. Quarter Century Club, which we enjoyed immensely but we soon came to the realization that there is no place like the good old U.S.A. for comfort and pleasure. Just a reminder—our 45th Reunion comes up next year—May 30 to June 2.—**Karnig S. Dinjian**, Secretary, 6 Plaice Cove, Hampton, N. H. 03842

30

Once again the communications from and concerning our classmates are liberally sprinkled with notices of retirement. . . . **Ormond Lissak** retired on June 30, 1973 as Administrative Assistant for the Department of Public Works, City of Mountain View, Calif. . . . Upon the occasion of his retirement from Gulf Oil, **John Moriaty** was the subject of an extensive article in the April 1, 1973 issue of the Beaumont Texas, *Enterprise Journal*. After graduation John worked briefly for Bell Labs before joining Gulf Oil in 1935. During World War II he served as radar officer and executive officer of an anti-aircraft artillery group in Australia, the Trobriand Islands, Kiriwina, Hollandia, Noemfoor, Mindoro, and Mindanao. He returned with a Bronze Star and a desire never to eat pineapple again. His work since then has involved considerable travelling including electrical design work for a Gulf refinery in Italy, survey of electrical damage after a refinery fire in Venezuela, troubleshooting at the Gulf Oil of Canada Point Tupper refinery, and electrical design of a fertilizer plant in Korea and a refinery

in Spain. His initial retirement project is building a greenhouse.

John Lovejoy has retired as President of Lovejoy Construction Co., but does not indicate what his retirement activities will be. . . . **Wally McDowell** has retired as Research and Engineering Vice President of I.B.M. He and his wife are living in Naples, Fla., where he reports having seen **Jack Bennett** who winters in nearby Sanibel-Captiva. The McDowells have three sons: William, who is with Phillip Morris in Richmond, Va.; Alan, who is with Allen and Co. in New York; and John, who is in the advertising business in Minneapolis. . . . **David McIntire** has retired from U.S. Pipe and Foundry Co., in Birmingham, Ala., where he still lives. The McIntires have a son David, who is an architect in Hanover, N.H. . . . **Alan Bemis** has been elected a Trustee of the Woods Hole Oceanographic Institution. . . . **Allan McLennan** has retired from the N. E. Power Service Co., but "did not like idleness" and so is now working again as an electrical engineer for Charles T. Mann, Inc., in Boston. His work has taken him to Australia, Brazil and Hawaii. He has been active in school committee work in Wakefield, Mass., where he lives. His final comment, which had best not be quoted in full, is to the effect that his "feelings of loyalty are rather strained . . . when M.I.T. harbors people like Ellsberg . . . and Chomsky." . . . **Bob Lytle** has apparently retired from Rust Engineering Co., and is doing consulting work. He reports having seen **Paul Kimberlin** who is living in Pierce, Ariz.

We have at hand a delayed report that **Hugh Wallace** died on December 25, 1972 in Watsonville, Calif. The Alumni Register indicates that he was President of the Watsonville Press. Unfortunately, no further details are available.

Changes of address: **Clifford E. Hoar**, 112 Moffat Rd., Waban, Mass. 02168; **Barnet L. Rosenthal**, 8608 N.W. 59th St., Fort Lauderdale, Fla. 33313; Dr. **Morris F. Shaffer**, 165 Turrell Ave., South Orange, N.J. 07079; **Arthur F. Wildes**, 74 Fountain St., Clinton, N.Y. 13323; **S. George Lawson**, 1800 E Ocean Blvd., Apt. 14W, Stuart, Fla. 33494—**Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N.Y. 10036

31

It is indeed a pleasure to report that **Ben Steverman** and **John Swanton** have agreed to be Assistant Class Secretaries. As a result, I'm sure that we will have much better class news coverage than I alone have been able to do in the past. John Swanton, whose address is 27 George St., Newton, Mass. 02158, writes that he has recently returned from an extended trip in the British Isles. They were six weeks with another couple in England, Scotland and Ireland, camping from John O'Groats to Lands End to the tune of 6,000 miles. After that they ferried across to Ireland and covered that country. John is enjoying his retirement and wonders how he ever had time to work. Ben Steverman, whose home address is 260 Morrison Dr., Pittsburgh, Penn.

Claude F. Machen, '31

15216, says that Clare and he had a pleasant visit with Jan and **Larry Barnard** in Humarock, Mass., at the shore in August, where Larry has been going since 1925. He and Clare had such good times at the 40th and Mexican Fiesta Reunions that they are eagerly looking forward to our 45th. Betsy, the youngest of their five girls, is a senior at Mt. Lebanon School—the others are married. Faith, their oldest is in North Carolina with three children, Hope and Jule are neighbors in Mt. Lebanon, with two boys and one boy respectively. Their daughter, Clare, is in Cleveland with one boy, and Ben Jr., was married this year shortly after graduation and is now at University of Pittsburgh Law School. Ben will be retiring next August as District Manager of Taylor Instrument in Pittsburgh. Sounds as if John and Ben are enjoying life.

A recent publicity release tells of **Arthur A. Smith**'s appointment as Senior Vice President of Stone and Webster. Congratulations, Art! **Claude Machen**, Chairman and Chief Executive Officer of Boston Gas, is keeping his Company in the forefront by finalizing the merger of three New England Electric System gas companies with Boston Gas. . . . **Emile Grenier** has been most active recently in his anti-lock crusade. He is devoting full time to this activity and is backed by many other outstanding engineers in believing there will be about a three percent failure rate for car interlocks, consisting of failure to start, starting without locking belts, and ignition failure on the road. Unfortunately, space does not permit me to go into all details—other than to say Emile is well qualified to speak on this field. For those who are interested in obtaining more complete details, I am sure that Emile will be glad to supply them. His address is 2436 Fuller Rd., Ann Arbor, Mich. 48105. **Larry Barnard**, **Gordon Brown**, **Vincent Mango**, our class prexy **Howard Richardson** and yours truly attended the Alumni Officers Conference at M.I.T. on September 15. The meetings were well organized and I'm sure we all felt it was well worth while.

It was a great shock to learn of **Russ Pierce**'s death on Saturday, September 22. Russ and I have kept in quite close touch with each other, not only during various meetings, but also by ham radio. Russ was stricken on Point Rd., Marion, while returning home from New Bedford in a car driven by a friend. He was pronounced dead at the hospital where he was rushed. Our deepest sympathy to his wife, Alice, his four sons and six grandchildren. Sincere condolences also to the families of: **Stewart M. Davis** who passed away on March 10, 1973; **Gordon D. Shellard**, who was deceased on July 13, 1973; **Meyer P. White**, who died suddenly on November 5, 1972 and **James J. Mazzoni**, deceased on March 30, 1973.—**Edwin S. Worden**, Secretary, 35 Minute Man Hill, Westport, Conn. 06880; **Ben W. Steverman**, Assistant Class Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216; **John R. Swanton**, Assistant Class Secretary, 27 George St., Newton, Mass. 02158

32

With deep regret I must report the sudden passing of our past president **Harry L. Moore, Jr.**, at the Greenwich Hospital, Greenwich, Conn., September 10, 1973. Harry was one of our most active Alumni members. In addition to his recent term as Class President he served as a member of the Educational Council of the M.I.T. Alumni Association, and a Director of the New York Center. A long time resident of Greenwich, he was very active in community affairs as an elder of the First Presbyterian Church, a past president of the Greenwich Taxpayers' Association, and an enthusiastic yachtsman serving at the time of his death as Commodore of the Indian Harbor Yacht Club. Harry spent most of his career with the Mobil Oil Corp., and was currently assistant manager for purchasing of the corporation. He was predeceased by his lovely wife, Margaret, who had contributed so much to several reunions. Harry is survived by a daughter, Eleanor D. Moore, a son Harry L. Moore, III, both of New York City. In addition, he is survived by his mother, Mrs. Harry L. Moore, Sr., sister, Miss Anne Oliver Moore, both of Greenwich, and a brother, William Moore of San Francisco, Calif. I know you all share with me the sorrow of this great loss to our Class and the Alumni Association and the family of this devoted, dedicated and loyal son of M.I.T. Our deepest sympathy goes to his family.

May I take this opportunity to extend to all of you the best wishes for the season.—**John W. Flatley**, Secretary, 6652-32nd Street N.W., Washington, D.C. 20015

33

Well, folks, inasmuch as you have received a standard copy of the interim letter, you are more than up to date on the gossip—'33 style. This column is written a week after the mailing of the letter, and, news from the faithful (?) is better than scarce; it is almost non existent. Earliest from anyone is a card from **Beau Whitton**, who allows that they were sorry to miss the 40th, because, they are (were) trying to sell their house, so as to move into an apartment. So, Beau and Daphne are sort of tied down. Beau says that they

Ed and Gladys Lockman at the 1933 40th Reunion

might still make their New England trip if it can happen before August 15, and if not, they might fly to New Brunswick in the early fall: interim weekends in the Blue Ridge Mountains. Many thanks, Beau, and best to you both.

We have two short ones from **Cal Mohr**, a week or so apart, mostly asking questions about some addresses. Previously Cal asked how the Kimball Fund is going. Of course, I did not know, and as that sort of info is available to all of us, I allowed Cal to find out himself and he came through with a bang. I got a copy of an M.I.T. interoffice memo which had been sent to Dayton Clewell, dated July 31, 1973. I quote: "The **Robert M. Kimball** '33, Memorial Scholarship has been used in support of students with established need. Established by the Class of 1933 as a memorial, it supported four students in '72-'73 at a total cost of $4620. In our stewardship of this fine award, we make every effort to select needy students reflecting both the full qualifications of the expressed preference of the Class of 1933, and the high caliber necessary to deserve the Robert M. Kimball Scholarship award" signed by L. E. Maguire, Assistant Director. Fellas, I have quoted the memo almost in full, as it was short, and it tells a complete story of the Kimball Fund, raised by the Class, almost 100 per cent by the efforts of **Jim Turner**, Ex-President of his class. Cal Mohr observed that the amount of over $4000 is far above what he (or I) would expect from that fund. We as a class sure did something right that time.

Further on, Cal finds that **Munroe Kessler** has been transferred from Wierton, W.Va., and is now Assistant Veep in charge of Quality Control for National Steel. Come, Munroe, let's have something personal like where you were transferred to, and something about the family. . . . We have a fine letter from **Bob Forbes**, late September. Bob sent some photos from his 40th slides to me, as custodian. It turns out that T.V.A. is now forced to get along by itself, as Bob has retired. He now wonders how he found time to work. The time, now, is spent at Bob's hobby, arts and crafts at shows and fairs. After the 40th Bob and Betty visited the southern Maine shore and SW New Hampshire with the crafts in mind, and he says that they bought three gallons of maple syrup. He did look a bit overweight. Bob has continued his interest in the Barbershoppers, with competitions in local and regional events. Bob and Helen are looking forward to the next reunion, because they enjoyed the 35th and 40th so very much. That is a fine letter, Bob.

Folks, that is all the personal stuff on hand, but we do have a report on the September Alumni Officers Conference; a really great event, not for the first time let me assure you. Without having made a count, there must have been close to 300 Alumni Officers from most classes, starting with 1896, with the following from '33: **Guido Garbarino**, **Bill Klee**, **Burt Webster**, **Westy Westaway**, and **John Wiley** and **Henderson.** I took little personal part, as I had a lingering flu bug, but got there every time for short looks. Briefly, an Alumni Officer is far more than those elected by the classes. Every man and woman who works for the Alumni Association in any capacity whatever, is an Alumni Officer. This includes, among others, the Educational Council, the Alumni Council, all Alumni Fund workers (there are many), not to mention class officers, elected. As one may easily see, this is a big thing, which further includes participation by the Faculty, Administrative Officers, and the whole Alumni Association Staff. I can't begin to list all that was covered, but may I suggest that the following booklets might well be available through the Alumni Association: Admissions Information, the Annual Report by the Alumni Association, and the Annual Report by the Alumni Fund (this one is really marvelous). You can't lose by asking for any or all of these reports, as the Institute must have enough left over for alumni. Failing there, write me and I will LEND any of them for brief periods.

There have been a few of the usual address changes: **Alfred P. Bruce**, CH; **Maurice G. Green**, CM; **Frederick S. Kline**, EE; **Francis O. Merchant**, AR; **Charles F. Payne**, CH; **Robert P. Sheperd**, AA; **Raymond Sohn**, GE; **Jack T. Turner**, MG. Their addresses are available by the usual method, that is via letter, which includes a family story, to the Secretary.

We have lost a few more of ours by the final event; and we are always at a loss to have to report these items involving passing of our fellows. In April, '73, **Harrison L. Jewett** passed away; in February '73, **Chauncy W. Raycroft** passed on; also in February, **Richard E. Wheeler** passed away. Your Secretary has written the bereaved widows. Fellows, close friends of these fellows who are gone might well drop a line to the widows or survivors.

I know that they would appreciate it. You will note that this gets to you near Christmas time, so Leona and I take this opportunity to extend to you all our best and most sincere wishes to you and yours, for a Very Merry Christmas and surely a Happy New Year. Just one more bit, fellas; I have never written a column that I hated to write more than this one, on account of the fact that it is the shortest I ever wrote. However, I handled it this way for considered reasons, I hope valid. Why not write me for a personal comment? See new address.—**Warren J. Henderson**, Secretary, 1079 Hillsboro Beach, Pompano Beach, Fla.

34

I was happy to receive, from what must be a justly proud wife, a leaflet that covered the award to **Karl A. Gardner** of the Max Jakob Memorial Award for 1972. The presentation was made in August at the National Heat Transfer Conference and the citation reads in part: "for his outstanding contributions to the design and evaluation of industrial heat transfer equipment during a period spanning four decades . . ." Karl is really part of an M.I.T. family; his father graduated in 1911 and his son in 1968. As might be expected, he has had a distinguished professional career. His original training in petroleum refinery operations came with Cities Service, then Karl went on to higher levels of responsibility to Chief Engineer of Griscom-Russell Co., and to Vice President of Engineering with Yuba Consolidated Industries. Since 1962 he has served as Senior Staff Consultant, first with M.W. Kellogg Co., and currently with the Liquid Metals Engineering Center at Atomics International. In these various positions he has been awarded nine patents and has contributed 15 significant technical publications. . . . Throughout his career Karl has devoted a great deal of time and energy to a wide variety of professional societies and trade associations. His contributions were recognized by his election as a Fellow of the A.S.M.E. in 1971, and he received world-wide recognition when he was invited to serve as co-chairman and guest lecturer at the 1972 Seminar of the International Centre for Heat and Mass Transfer in Yugoslavia. Both our Class and M.I.T. can feel honored to include a member with such accomplishments.

And now to catch up with some of the Alumni Fund notes that have accumulated. **Samuel S. Goldstein** writes, "I am working as a management consultant for the George S. May International Co. As of May 6, 1973 I became a grandfather for the first time—the baby, Kathy Elise Goldstein, was born in Phoenix where her parents live." It's only been as I've received some of these notes that I realized how many of our classmates were working at the Portsmouth Navy Yard. From **George M. Woodman, Jr.** comes: "I retired one year ago this June from the Design Division, Portsmouth Naval Shipyard and I am having a real ball. Have been really busy working on and about my new home on the York River, working on my boats, working my amateur radio station W.I.A.P.M. I don't quite see how I ever found time to go to work at the Yard! Hi!" George is finding out what I did several years ago. Another infallible recipe is to get yourself involved with a town board like the Conservation Commission. . . . A while back we had an item that **William Main** had retired but I didn't realize he was practically in my back yard until he wrote, "Have retired to a windy hill on Cape Cod (Chatham) after 35 years with the New York Central and the Penn Central. Very busy with new activities but extend a welcome to any who stop by". Well, one of them is certainly going to be me—we're only seven miles apart.

Arthur J. Leydon wrote, with unfortunately some unhappy news. "Still at Dewey and Almy Chemical Co., Division of W.R. Grace, as Senior Group Leader, Research. Lost my wife suddenly at sea on way home from West Indies last August, 1972. Have son 21 years old in electronics at Unitrode and my daughter 23 gets married May 19." We are certainly sorry about Mrs. Leydon's death, especially apparently on a vacation trip. Arthur had also written something about his hobbies but after the flap of the envelope got torn off, all that was legible was "scout leadership training".

The final one seems almost incredible. It is from **John Hopkins** and simply says, "Begin residency in neurosurgery July, 1973," if I read the date correctly. John was Course VI and if this cryptic note means he is starting a whole new career at this stage of the game, that is really something!

Presumably you will be reading these notes sometime before Christmas. May we wish you all a happy holiday season.—**Robert M. Franklin**, Secretary, Satucket Rd., Brewster, Mass. 02631; **George G. Bull**, Assistant Secretary, 4961 Allan Rd., Washington, D.C. 20016

35

Hail to the Champion! **Leo Beckwith** won the 13th Annual Class Golf Tournament in a recent match with **Art Marquardt** at the Kernwood Country Club. **Bob Forster** and **Allan Mowatt** completed the foursome. Leo started off by making an eagle on the first hole, a par 5, the first one he has ever made and was never behind in the match. In the Consolation Flight, **Ham Dow** broke 80 for the first time and won over **Fran Muldowney**. Ham's 79, with a 17 handicap was made on Rancho Canada's West Course at Carmel, a very tight layout rated 70.3 and at a most opportune time during the General Electric Golf League's final tournament of the year. Needless to say, Ham has another trophy for being G.E.'s Outstanding Golfer.

While we are talking about golf, I should tell you that I played my annual match with **Sid Grazi** while I was in Denver in mid-September. I had driven my twin sons out to start their freshman year at Colorado State and was resting up for the long trip back alone. During the course of two evenings spent with Sid and Anne I caught up with their activities and family. Sid's Titan Construction Co., is busy working on several millions of dollars worth of projects. Anne has developed her own business (Spotted Faun Enterprises) for which she makes and sells leaded glass objects. Terry, 23, graduated from Colorado University last June and was backpacking through Europe. Jeff is working as a technician at Howard Industries and was in the process of moving from home to an apartment of his own. Mike is a junior in high school working part-time evenings.

While in Denver I also had a chance to see **Otto Zwanzig** and learn the latest about his family. His wife Alice is working with the Colorado State Social Services and travels the state. Daughter Lisa spent last year at Wasseda University in Japan and this year is with the Peace Corps in Zaire teaching English to French-speaking Africans. Son Peter is at Cornell Law School after three years in the navy and his wife Joy is teaching Chinese at Cornell University. In the meantime, Otto, the entrepreneur, is keeping his eyes open while doing some consulting. . . . On the way home I went through Rockford, Ill., and had a brief chat with **Charles Debes** and visited his two nursing homes. Things are a bit chaotic at the moment with construction just completing at the second unit and getting people and things moved in and organized. . . . Ann and **Sid Grazi** had recently returned from a trip to Amsterdam, Moscow, Leningrad and several Scandinavian capitals. A detailed account of an exciting experience in Russia was published in the September 7 issue of the *Intermountain Jewish News* which Sid will be happy to send to you. I couldn't do it justice by condensing it further, but you really should read it and have Sid expand it.

John Brosnahan wrote from his home in Hellertown, Pa., to answer my question in the Class Notes as to where he had been out of the country. Here's his reply: "My son-in-law is with the U.S. Embassy in Bujumbura, Burundi. My daughter had her second child last fall in Nairobi, Kenya. So we went to Burundi via Athens and Nairobi and had a chance to see a couple of game parks. Burundi is a small independent country on Lake Tanganyika just east of the Congo (now Zaire). Although Bujumbura, the capitol, is fairly well up to date because it was a Belgian colony, the rest of the country is a different world. Most of the people live in huts made from sticks, mud and grass and subsist on a little garden patch. There is a group of hippos that live on the lake front within the city." Thanks very much for your note, John.

I have the sad task of reporting the loss of four of our classmates: **James F. Notman** on July 24, 1973; Dr. **Lan J. Chu** on July 25, 1973 and **Charles S. Symonds** on October 17, 1972. . . . Jim Notman had lived in Marion, Mass., since 1948 and leaves his wife Helen, three sons and a daughter. Dr. Chu of Lexington, Mass., was Webster Professor of Electrical Engineering at M.I.T. and is survived by his wife Grace, two sons and a daughter. . . . Dan Finucane worked for Eastman Kodak for 33 years and leaves a son and a daughter. . . . Charles Symonds lived in Auburn, N.Y. On behalf of the Class I extend our deepest sympathy to the members of the families.

With these notes comes my wishes for a happy Christmas or Hanukkah and a wonderful New Year and may you resolve to write your lonesome Class Secretary at least once a year.—**Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

36

While camped at Moraine Park in Rocky Mountain National Park in September, your Secretary picked up a copy of *The Denver Post*, to start fires with, of course, which featured the announcement of an electronic tester developed in the Loveland Instrument Division of Hewlett-Packard. **Bill Hewlett** is in the news again as is "Bunkie" **Knudsen** whose efforts at the White Motor Corp., are being carefully watched by many. . . . We have news of quite a different nature having to do with one's extracurricular activities. **Joe King** has designed a single shaft sulky for harness racing. Joe, who is with N.A.S.A., and lives in Ormond Beach, Fla., has been harness racing for more than twenty years. . . . **Boynton Beckwith** writes that he is "completing 37 interesting, challenging and satisfying years with United Air Lines, with three to go 'til I retire. Children and grandchildren spread to the four winds, but thanks to airline fringe benefits this poses no problem. Still in the Chicago area and looking forward to retiring elsewhere. The three "C" states and Oregon are in the running". We'll be happy to welcome him to Connecticut if that C turns out to be his choice. . . . **Alfred Dasburg** has moved to Santa Fe from Buffalo and **George Ray** to Libertyville, Ill., from Belleville, Wash. **Carl Hedberg** has returned to the Denver area from Southern California. If anyone wants the address of anyone above I will provide it happily in exchange for news!

The Alumni Office reports the death on August 30 of **Daniel B. M. Finucane**. He had been living in Pittsford, N.Y., at 222 Longmeadow Circle. I have no further information.—**Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

37

Am delighted to report that on September 15, 1973 **William B. Bergen** was awarded the 1973 Bronze Beaver for his distinguished service to the M.I.T. Corporation Development Committee, Alumni Fund, Educational Council, M.I.T. Club of Southern California, Visiting Committee on Sponsored Research, and the Los Angeles Area Alumni Fund Council and its Leadership Gifts Program. . . . Last year **Leon A. Menzl** was appointed Director of Manufacturing, Electrical Division, Consolidated Foods Corp., Old Greenwich, Conn. . . . **Louis D. Bloom** celebrates his 34th wedding anniversary with wife Grace on January 21, 1974. He is still with General Electric Co., Nuclear Energy Division, Breeder Reactor Department, San Jose and Sunnyvale, Calif., with seven years to mandatory retirement. He reports his health is good and he is playing tennis year round but unfortunately no squash. . . . **Ed Hobson** is Vice President and General Manager of Aladdin Synergistics and Chairman and President of Temprite International which serves over 80,000,000 meals a year. Eight of his 11 children are still at home. He reports that for the past five years he has commuted between Nashville, Tenn., and Cranford, N.J., in the winter, and Rye Beach, N.H., in the summer. . . . **Charles Witsil Jr.**, is Engineer Specialist for New Products, E. I. duPont de Nemours and Co., and Treasurer of the Nashville, Tenn. Philatelic Society. He claims to be Vanderbilt Hospital's favorite cancer patient with six operations in seven years.

Dr. **P. William Bakarian** and wife Helen have a new address at Suite #210 Regency South, 3750 Galt Ocean Dr., Fort Lauderdale, Fla. 33308. . . . **Jerry Salny** is President of Imported Auto Center and Salcorp., and Treasurer of Salny Enterprises, Morristown, N.J. The *N.Y. Times* reports his second marriage to Dr. Abbie F. Shapiro who is Professor of the Psychology Department at Montclair State College, Montclair, N.J. **Joe Keithley** writes from Cleveland that he is still going strong. He has relinquished the presidency of Keithly Instruments and is now Chairman of the Board.

It is with deep regret that I report the death of **James G. Loder**. Jim retired earlier this year as Manager of Proposals and Presentations of Raytheon Equipment Divisions, Wayland, Mass. Our deep sympathy goes to his wife Dianne, three sons and five daughters and their families. You will recall that we reported in June that Jim married Dianne in 1971, after losing his second wife Alice to cancer in 1970. Jim and Dianne's daughter, Erin Elaine is one-year-old.—**Lester H. Klashman**, Assistant Secretary, 198 Maple St., Malden, Mass. 02148; **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, Mass. 02155

39

Last month I reported briefly on Professor **Louis D. Smullin**'s appointment as Dugald Caleb Jackson Professor of Electrical Engineering. Here are further details of Louis' career: He has been at M.I.T. almost continuously since 1941 when he joined the staff of the wartime Radiation Laboratory. He helped plan the Lincoln Lab in 1952 and became head of the Radar and Weapons Division. He returned to Cambridge in 1955 as Associate Professor of Electrical Engineering and became Professor in 1960, concentrating in microwave beam studies. He and his students were the first to bounce a laser beam off the moon, in 1962, detecting reflections back to earth. In 65-66 he spent a year at the Indian Institute of Technology, at Kanpur, India, having been a member of the M.I.T. faculty committee earlier that had recommended that M.I.T. help organize that Indian university. In 1966 he was named head of the Department of Electrical Engineering, which now has the third largest undergraduate degree program of computer science at the Institute.

This is an old news item, but did you know that **Thomas MacMaster Leps**, who heads his own firm in Atherton, Calif., was one of 70 elected to membership in the National Academy of Engineering? He was so honored for his work in the field of soil mechanics, design of earth and rockfill dams, and safety of earth structures.

Class news is brief this month. If thirty-niners want output, I need input!—**Oswald Stewart**, Secretary, 3395 Green Meadow Circle, Bethlehem, Pa. 18017

40

Belatedly, we have received the additional information from Mrs. Matthews that **Owen Matthews, III**, Course IX-B, died of a heart attack on December 13, 1972 on the island of Kauai, Hawaii while they were on vacation.

This being the only news this winds up the column for 1973. For more news and more pleasant news, resolve to write to Al in 1974. With best wishes for a Merry Christmas and a healthy and prosperous New Year.—**Al Guttag**, Cushman, Darby and Cushman, 1801 K Street, N.W., Washington, D.C. 20006

41

Your Secretary is alive and well and living on Nantucket, which may be a surprise for most of you since no Class Notes have been submitted since my fickle secretary left me for an acting job. In any event, I am now back in touch and happy to report that summer is over on Nantucket. Labor Day becomes the happiest day of the year out here, where we can once again reclaim our island, watch the moors change color, enjoy the greatest Indian Summer in America, swim and fish and enjoy the calm that is restored. Why don't some of you come out and enjoy the finest season here.

Technology Review had invited all of the Secretaries to a meeting in Cambridge on September 14, which your Secretary was unable to attend, asking for ideas on what we would like to see in this *Review*. Since we could not attend, we are asking you former class members to tell us what you thing would be of pertinent interest. What do you like or not like about what you hear from Cambridge. What would you like to see in Class Notes, Institute news, articles and editorials. Let us know and we will pass it on.

Congratulations to **Robert T. Parry** on his election as Vice President of the Edison Company. . . . Congratulations also to **Kenneth Spaulding**, appointed Manager of American Smelting and Refining Company's new copper refinery to be built in Amarillo, Texas. . . . It really looks like Texas was in the news with **George W. Clark** presenting a program to the El Paso Illumination Engineering Society entitled "New Directions in Lighting Research and Application." George is very active with the Illuminating Engineering Research Institution.

A note from **Calvin D. MacCracken** merits being quoted in toto: "Since I was only at Tech one year, graduating in IX-B, after graduating from Princeton, not many classmates know me. You may be interested to know I won the National Senior Squash Championship 1970-1973, New Jersey Tennis Champ '72-'73, and just received my 75th patent in my company which I founded 26 years ago. The latest, to issue in September '73, is the "Icemat" Skating Rink, a low-flow high ΔT temperature averaging concept going great guns commercially this year." Good to know someone in the Class is not only successful commercially but in good shape. More than you can say for your Secretary.

We have many notes on activity in the ecology field by members of the Class all over the country. It is our responsibility! My file just unearthed some Christmas cards from last year, which shows I'm not too far behind, but since you will be getting this as the December issue this year—please enjoy the blessings of the season, and know I will try harder this coming year. That comes under the heading of resolutions—not meant to be broken.—**Michael Driscoll**, Secretary, 23 Broad St., Nantucket, Mass. 02554

42

Donn Barber writes that he stopped overnight in Tacoma en route to Japan last Spring and met with **Earle Foote** and his wife. Donn does not give us any information about himself, but did report that Earle, in addition to his job at Boeing, raises, shows and buys and sells cattle; sails and otherwise enjoys life in Tacoma.

Our Class was well represented at the A.O.C. in Cambridge by Mildred and **Paul Hotte**, Sandy and **Lou Rosenblum**, Carole and **George Schwartz**, Betty and **Charlie Speas**, **Bob Fay**, **Jim Littwitz** and your Secretary and spouse. Jim is starting a Kodak sponsored stint at Harvard Business School and will be commuting, more or less, from Rochester to Cambridge for the next few months.

Although I have not been able to research it completely, I think that our Class has a "first" in having received two Bronze Beavers in the same year! One was awarded to **Paul Hotte** with the following citation: "Commitment, dependability, enthusiasm, humility, and imagination are qualities that have determined the Institute's greatness. This tribute symbolizes his abundance of each exemplified in generous service to Class, to Institute Committees, to the Alumni Fund, and to his local M.I.T. Club. Each has been enriched by his efforts, and the Association has been enriched by the example he represents to all alumni". The other Bronze Beaver was awarded to **Hugh Schwarz** with the following citation: "As leader and worker in local, regional and national activities, President of two clubs, member of the Corporation Development Committee and of the Corporation Visiting Committee for Nutrition and Food Science, Regional Chairman of the Educational Council, worker for the Alumni Fund, and as an active participant on many other boards and committees—he has contributed importantly to many facets of the Association and the Institute".

Our congratulations to both of them. Although these notes are being written during Indian Summer, because of long lead time on deadlines, it is time to wish everyone a Merry Christmas and a Happy New Year!

How about starting 1974 with a short note to me about yourselves and about any other classmates you run into?—**Ken Rosett**, Secretary, 191 Albemarle Rd., White Plains, N.Y. 10605

44

The following stalwarts attended the Alumni Day this year: **William Boschen**

and his wife, **Jacquelyn Findlay**, **Robert Horn** and his wife, **John Hull** et al, Mr. and Mrs. **Robert Ilfeld**, **Peter Matthews**, **Theodore Nathanson**, **Norman Sebell**, Mr. and Mrs. **Joseph Snyder** and Mr. and Mrs. **Newton Teixeira**. Taking the rest of the notes alphabetically, we have a report that **Robert E. Benedict**, President of American Mail Lines, has been appointed director of several organizations: Natomas Co., American Mail and American President Lines, National Cargo Bureau, as well as trade and finance groups.

McGraw-Hill Publications announced that **Carroll W. Boyce** has been appointed Editor of Fleet Owner, a monthly magazine for administrative, operating, and maintenance managers of motor vehicle fleets. Carroll rejoined McGraw-Hill after serving as Director of the Motor Truck Manufacturers Division of the Motor Vehicle Manufacturers Association. He originally joined M-H in 1946. . . . **K. S. Brown** dropped a note expressing interest in an M.I.T. Club in Old Saybrook, Essex, and the Old Lyme area. If any of our Class are nearby, please contact him. . . . **Elias D. Cirelli** reported that he is a design engineer with Roytype, a division of Litton. Roytype is a manufacturer of fabric and carbon ribbons for typewriters. Do you also make the new cassettes? **Dean Henry Cohen** of the Center for New York City Affairs is back in the news. He has been elected Chairman of the Council of University Institutes for Urban Affairs. (Academia sounds as complex in organizations as large industries.) The Council has memberships from more than 100 institutions in the U.S. and Canada. It supports development of university research, education, and service programs in urban affairs, and enhancing urban affairs as a professional and academic field. . . . **Arthur F. Dershowitz** wrote that he is Manager, model development, with the General Electric Co., planning development staff in New York. His elder son, Daniel, is a sophomore at M.I.T. and is not getting much sleep. As Art says, some things don't change. Speaking of children, time is flying for our Class. . . . **Wallace P. Dunlap** wrote that his daughter, Ann Bowman, presented him with a granddaughter last fall. His oldest son, Sandy, was married in Waltham, Mass., last summer.

The *Boston Globe* had an article about **Jack Frailey**. The veteran lightweight crew coach at M.I.T. was elected Chairman of the U.S. Olympic Rowing Committee. Jack is one of three U.S. delegates to the International Federation, which is the governing body. Unfortunately for us, he had to leave M.I.T. Two newspapers reported that **Dean B. Harrington** has been elected a Fellow of the Institute for Electrical and Electronic Engineers. This highest membership grade was conferred for his "contributions to the design and performance analysis of large steam turbine-drive generators." Harrington, who is author and co-author of numerous technical papers, is widely recognized as an authority on reactances of electrical machines. Since 1967 he has been Manager of Generator Advance Engineering, Generator Department, at General Electric, Schenectady. A registered professional engineer, Dean represented the U.S. at meetings of the International Electrotechnical Commission in Moscow, Tokyo, and Rome. The Schenectady section of the I.E.E.E. honored him at a banquet. . . . **Paul Heilman** wrote that he is looking forward to a big 30th Reunion next year. . . . He had supper with **Sten Hammarstrom** in Los Angeles. Sten is with C. F. Braun and is engaged in some very interesting projects.

Two of our Class were singularly honored by election to the National Academy of Sciences. **Lawrence R. Klein** is Benjamin Franklin Professor of Economics at the University of Pennsylvania. **James Ross MacDonald** is Clinical Associate Professor of Physics in the medical school of the University of Texas, and Director, Central Research Laboratories, and Director, Corporate Research and Engineering at Texas Instruments. The T.I. newspaper pointed out that Ross was elected to the National Academy of Engineering in 1970 and currently serves on the N.A.E. Council. With his election to N.A.S., he is one of about 50 people who are members of both academies.

If you need advice on machine design and process problems, call **George H. Manning**. George is now in private practice as a consultant. . . . **Dean C. Picton** dropped a note that he was elected a director of the Christian Businessmen's Committee, International, at the conventional in Portland last fall. He also planned to be a delegate to the Southwestern Pacific Conference in Perth, Australia, this past spring. (Ed. note: I wish I had his abilities—I get sent to Fayetteville, N.C. Actually, it was a good trip since I witnessed the annual fire power demonstration of the U.S. Readiness Command featuring the 82nd Airborne troopers.) . . . After almost three years as Chief Executive Officer, Chief Financial Officer, and Director of a small, high-technology public (O.T.C.) company, **C. Reginald Robba** has decided to concentrate on new venture opportunities. Good Luck, Reg. . . . **Paul Robinson** noted that I had erred last fall and put him into the wrong part of the Navy Department. I had him in the Marine Corps when he really is with the Chief of Naval Operations, Information Systems Division. Sorry about that, Paul. He also was looking ahead to the 30th Reunion next year.

Lieutenant Commander **William C. Sadler** noted that during a trip to Saigon, he talked to **John Lednicky** in Manila from their burned out international airport. Bill remarked that the scene in Southeast Asia is changing rapidly. . . . Finally, the Bell Labs News reported that **Seth H. Washburn** has been appointed Executive Director of the Salary and Technical Personnel Administration Division of Bell Laboratories in Murray Hill, N.J. Seth is Executive Director of the Toll Switching Division with responsibilities for laboratories in Columbus, Ohio, and Naperville, Ill. Since joining Bell Labs in 1947, Seth was involved in the development of electronic and electromechanical switching systems. On the side he co-authored a book, *The Design of Switching Circuits*. Drop me a note with your activities.—**John G. Barmby**, Assistant Director, Procurement Division, U.S. General Accounting Office, Wash., D.C.

G. Robert Keepin, '47

47

As the cool weather settles in and we in this part of the country put away the sticks for awhile, it is a pleasure to report that **Al Richardson** was the winner of the first annual M.I.T. Greater Boston Alumni Golf Tournament held at Charles River. Al not only won the gross with a two over par 74, but also won the net with a 67. He was one under par for 15 holes which indicates that he may have propensities for a little sandbagging. Anyhow, again congratulations Al; we all need strokes.

Representing our Class at Alumni Day were Mr. and Mrs. **Harl Aldrich**, Mr. and Mrs. **Claude Brenner**, Mr. and Mrs. **Harold Brown**, Mr. and Mrs. Hugh Flomenhoft, **Bob Hagopian**, **Dave Knodel**, Mr. and Mrs. **Richard Merrow**, **Ruth Mileson**, **William Page**, Mr. and Mrs. **Marty Phillips**, Mr. and Mrs. **Arnold Putnam**, **Al Richardson**, Mr. and Mrs. **Jack Rizika** and Mr. and Mrs. **Don Van Greenby**.

From the clipping services, we see that **Arthur Zito** gave the commencement address at Shenandoah Valley (Pa.) High School. He is Professor of Management and Director of the Executive Education Department at Drexel University. . . . **Claude Brenner** is on the Executive Committee of the M.I.T. Club of Boston. . . . **Kermit Greene** has been named Divisional General Manager of St. Regis Paper Company's Laminated and Coated Products Division in Attleboro, Mass. He has held various positions in the Boston area with St. Regis and the predecessor company since 1951. . . . Dr. **G. Robert Keepin**, group leader in charge of the Nuclear Safeguards Research and Development Program at the Los Alamos Scientific Laboratory, was named winner of the American Nuclear Society Special Award for 1973. The award for Nuclear Material Safeguards Technology was presented to Dr. Keepin "for his early recognition of the need for non-destructive assay of fissile materials, his demonstration of a practical method for accomplishing this goal through passive and active interrogation and his leadership in implementing these techniques and gaining wide acceptance for their use."

From the mailing list, note that **Bob Connors** has moved from New York to

Charlottesville, Va. Maybe he will drop a note. . . . To all a Merry Christmas and Happy Holiday Season. Let us hear from you.—**Dick O'Donnell**, Secretary, 28516 Lincoln Rd., Bay Village, Ohio 44140

48

Gardner S. Rogers has spent the last two years as General Manager of Civil and Mechanical Maintenance, Proprietary Limited, a railway construction and maintenance company, and as State Manager of Fluor Australian Proprietary, Limited, an engineering and construction company. Gardner and his family are starting their third year in Western Australia and are thoroughly enjoying living in Perth on the Indian Ocean. His two daughters Ann and Barbara, ages 17 and 14, attend school in Perth. . . . **George Collins** is Vice President of T.R.C., The Research Corporation of New England. T.R.C. is a 60-man group of consulting scientists located at Wethersfield, Conn., and engaged in environmental surveys and pollution abatement. . . . **Don E. Davenport** is Vice President of a small company that makes most of the small explosive devices for Apollo. Until project Shuttle goes ahead they are doing military and commercial work. Don's stepson, Larry Kells, is a graduate student in Math at M.I.T. . . . **James E. Manson** had three graduations in June. Cynthia (Mrs. John Gardella) graduated from Mills College. Priscilla graduated from Colby Junior and Mark completed high school. . . . Colonel **Bruce Morrell** is a project manager in the F-14B/F-15 Joint Engine Project Office, Aeronautical Systems Division, Wright Patterson A.F.B. . . . **Howard B. Gibbs** retired from the navy in 1968 as a Commander and is now Safety Engineer for Employer's Casualty of Dallas, Texas. . . . **Dick Gaunt** retired from the navy and is employed at the Naval Coastal Systems Laboratory, Panama City, Fla., as an Operations Research Analyst. Other '48ers in Panama City are **L.O.G. Whaley** who is C.O. of the Laboratory and **Charles T.** "Frenchy" **Fontaine** who is a broker with A. G. Edwards and Sons, Inc. . . . **Scott D. Thayer** is a co-founder of a research and technology company, Geomet, Inc., in Rockville, M.D., founded in 1967. The company has diversified into health care systems, environmental management, mining and exploration and has made several corporate acquisitions. All is going very well both professionally and personally. . . . **John H. Dedrich, Jr.** has a new position as General Director, Metallurgical Research Labs of Reynolds Metal Company in Richmond, Va.

Chester R. Gates missed our 25th Reunion because of the Air Show in Paris. Chester is Vice President International for Northup Corporation. . . . **James B. Morris, Jr.** is enjoying semi-retirement with his family in the lovely foothills of the Adirondacks. Jim has been backpacking, fishing, snowmobiling and hunting with just enough work thrown in to keep alert. . . . In May, the Class of 1948 Award for athletics was presented to David R. Wilson '73, originally a catcher, then a left-fielder after an arm injury, and also captain of the baseball team. At the same Awards Convocation, the Graduate Student Council Awards for Outstanding Graduate Teaching were presented to five professors including **Ed Lorenz** of '48. . . . Phil Closmann of Shell Development Co., in Houston attended the M.I.T. Club of Mexico City 25th Anniversary last April. . . . **Joseph E. Sullivan** was appointed National Marketing Manager of rod products at American Brass Co. Joe lives in Newton, Conn., with wife Patricia, two sons and two daughters. . . . **Bob Bliss** was elected to the Board of Directors of the M.I.T. Club of Boston for the current year. . . . **John Brady** was appointed Head of the Weapons Department at the Naval Underwater Systems Center, Newport, R.I. . . . **Barry Bloom** was elected to the Board of Directors of Pfizer, Inc., New York City. Barry is Vice President of the corporation and President of Pfizer Central Research. Barry lives in Lyme, Conn., with wife Joan and their three children.—**S. Martin Billett**, Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

49

There are only a few notes this month—and just as well since I am writing by hand in Volta Redonda, state of Rio de Janeiro, Brazil. Two alumni fund notes: from **Ernesto Zapata**, "Manufacturing Director for Columbian Official Oil Co., Ecopetrol—in charge of Refining, Petrochemical, Pipeline activities." . . . And **Blair Manning** reports his return to Peoria, Ill., on August 1 to become Sales Manager for Caterpillar's Mid-Americas Division, encompassing Mexico, Central America and Caribbean . . . "not quite the same as living in Geneva."

The Center for Naval Analyses, lineal descendant of the Operations Evaluation Group, hence the country's oldest organization performing operations research and systems analysis for the military services, and now an affiliate of the University of Rochester, announces the appointment of **Russell Murray, 2nd**, as Director of Review. Russell comes to this post by way of Greenman Aircraft Corp. (1950-1962), where he was missile flight test engineer on the Rigel project and later Assistant Chief of Operations Analysis; the Department of Defense (1962-1969); serving as Principal Deputy Assistant Secretary of Defense for Systems Analysis; and Pfizer International (1969-1973), as Director of Long-Range Planning. It all started with the S.B. and S.M. in Aeronautical Engineering at M.I.T. in 1949, 1950, now nearly 25 years ago . . . which leads smoothly to our final news item, a progress report on 1949's 25th Reunion, based on the third committee meeting, held at the M.I.T. Faculty Club on September 13.

The on-campus reunion will start with registration on Saturday June 8, and will continue through Sunday and Monday. The details of each day's activities are to be worked out by Ginny and **Paul Weamer**, Evie and **Joe Day**, Adele and **Ed Berley** and Pam and **Mickey Ligor**. Eighty double and 20 single rooms are available for us at McCormack Hall. Children will be housed in Baker—all at no charge. The off-campus reunion will start with a flight to Guadeloupe on Wednesday, June 12, for one week at Club Mediteranee ($154. per person for land accommodations; air fares still up in the air, but no more than $150., if we fill the charter), returning to Boston the following Wednesday. The open Tuesday, June 11, will be filled with "something different" dreamed up by the Weamers et al. **Russ Cox** proposes that we incorporate professional seminars—and associated tax savings for attendees—into the Guadeloupe trip. He will prepare a write-up for further consideration.

Make your plans now to join us for the biggest and best 25th ever. And budget now for your final contribution to our class gift—the Class of 1949 Visiting Professorship.

Seasons greetings to all.—**Frank T. Hulswit**, Secretary, Arthur D. Little, Inc., Acorn Park, Cambridge, Mass. 02140

50

R. Clay Burchell has been promoted from Clinical Associate Professor to Clinical Professor in the Division of Health Sciences, College of Medicine at the University of Vermont. He joined the Vermont faculty in 1968. . . . **G. A. Lessells** was recently elected to a three-year term as a director of the American Institute of Chemical Engineers. . . . In the May, 1973 issue of *Union Carbide World*, **John E. Anderson** received recognition for the successful solid waste disposal pilot plant in Tarrytown which has been operating for more than a year. The system, patented in April, 1973, will be demonstrated in South Charleston to confirm laboratory results. Noteworthy features of the system: *no* pollutants are discharged into the atmosphere *and* the system produces five times more energy in the form of fuel gas than it uses.

Plans are underway for the 25th Anniversary of your graduation from M.I.T. President, **Bob Mann**, has announced the appointment of **Margaret Coleman**, as Reunion Chairman in 1975. Please keep this important date in mind and look for more information on this in the near future.—**John T. McKenna**, Secretary, 2 Francis Kelley Rd., Bedford, Ma. 01730

51

I hope you have all had a pleasant and relaxing summer. We have been busy collecting news items from various members of the Class and I am pleased that it is now my turn to report to you on what we have heard.

We have news that **Chris Bolta** is back in nuclear work after 12 years in the aerospace business. He is Chief Engineer on the liquid metal fast breeder reactor safety experiment at Argonne Labs. In addition to handling their 4 kids, Joy, his wife, is working as a psychiatric nurse.

Time marches on for **Ed Fitzgerald.** His daughter, who is attending Syracuse Law School, is going to be married this fall. Ed is Staff Consultant for Computer Communications in Los Angeles. . . . **Dick Kolk**

is another career changer. Last year he got a Ph.D. in Electrical Engineering from the University of Connecticut and is now Chairman of E.E. at RPI-Hartford Graduate Center. He would appreciate hearing from anyone who knows the whereabouts of **Jeep Kletskey.**

Dave Ragone has been named Dean of Engineering at the University of Michigan. Dave had been on the faculty at Michigan's College of Engineering from 1953 to 1962. He is also quite active doing consulting work with the U.A.W. relative to the automotive industry's efforts to meet the Clean Air Act standards. . . . Congratulations also to **Bob Woolworth**. He has been admitted to the partnership of Joseph S. Ward and Associates, a consulting geotechnical engineering firm located in Caldwell, N.J. He was also appointed Vice President of Joseph S. Ward International, Inc. Bob lives in Bloomfield, N.J. with his wife and five children.

Garth Coombs has relocated his wife, Margaret, and four kids to Johns-Manville Corporate headquarters in Denver, Colo. He continues as Senior Research Engineer. . . . **Dave Long** reports on interesting extracurricular activities. With his wife, Chris, he has written a mental health documentary, "Experiment in Love" and a screenplay currently in production, "So Long, Blue Boy". Perhaps Dave can give us a critical review of the two efforts. They certainly sound interesting. On a more prosaic base, Dave is systems engineer at Rockwell International. . . . Also at Rockwell International, **Edward Lays** is in their Columbus Aircraft Division working on the supersonic VSTOL fighter.

We have a new address for **Carroll White**: 638 Bad Homburg, Heuchelheimerstr 25 West Germany. Good luck in your new location! . . . **Irwin Manning** reports that **George Field** is now Head of the Harvard Observatory and is also Professor of Astronomy there. . . . Operating in the Government sector of our economy, **Jack Lowen** is with the Customs Bureau, Treasury Department as an analytical chemist. . . . At a talk to the L.I.A. Industrial and Electronics Manufacturers Council, **Bob Wedan** discussed the Department of Transportation's efforts to improve airport radar beacon systems, pilot-tower communications systems, detection of air turbulences and air collision avoidance. Bob also reported on the D.O.T.'s efforts to do something about the hijacking problem insofar as the truck industry is concerned.

Two notes of interest to those in the gas and oil industry, **John Dowds** has recently published an article in *World Oil* magazine discussing geostatistics as an aid in the discovery of gas and oil. John is a partner in Sigma Exploration Co., in Oklahoma City. . . . **Chiranjiv Batra** is Program Manager for the petroleum industry at Woodward-Envicon, Inc., in San Francisco. . . . Dr. **Louis Weinberg** is now on sabbatical doing research on digital filters and mixed lumped-distributed networks. . . . **Tom Meloy** is Vice President of Research and Development at Mel-Labs., Inc., in Springfield, Va.

Thanks to **Howard Levingston**, we hear that **Tom Dell** is Director of Planning for Educational and Consumer Products for the Mead Corp., in Dayton, Ohio. . . . Rockwell International seems to be getting more than its share of attention this month. However, we would like to take the time to congratulate **Bill Shenkle** on being appointed Vice President of Engineering for the Municipal Utility Division of that corporation. Bill has been with them since graduation and his division is located in Pittsburgh, Pa. . . . In distributing congratulations, I personally would like to take a moment to extend them to **Fred Lehmann.** As most of you probably know, Fred was recently appointed Financial Vice President and Treasurer of the Alumni Association. Fred is responsible for the overall financial management of the Alumni Association and becomes Director of M.I.T.'s $3 million annual alumni fund of over 22,000 donors. I am sure we all join in offering Fred, not only our congratulations, but also our pledges of assistance with his new responsibilities. Fred has been with the Alumni Association since 1959 and he and Betty Ann live with their four children in Boxford, Ma.

From the Aerojet Nuclear Co., in Idaho Falls comes word of the appointment of Dr. **Peter Lang** as Manager of the Thermal Reactor Safety Program. . . . Finally, **Norman Edelson** has been appointed Manager of Process Engineering at Corning Glass. Norman has been with Corning since 1955, and has served in various process manufacturing and engineering positions, primarily in the electronic component's division of the Corning Glass Co.

I am glad that we were able to report on so many classmates in this issue. I hope you will all keep sending in your notes and I will look forward to my next turn behind the typewriter.—**Samuel Rubinovitz**, Assistant Secretary, 3 Bowser Rd., Lexington, Ma. 02173. Other members of the "editorial staff": **John Dowds**, Assistant Secretary, 1800 N. W. 18th Street, Oklahoma City, Ok. 73106; **Marshall Alper**, Assistant Secretary, 1130 Coronet Ave., Pasadena, Ca. 91107; and **Fred W. Weitz**, Secretary, 4800 S. W. 74th St., Des Moines, Ia. 50321

54

Bob Anslow is with Rockwell International's Electronics Group and recently spent three months in England working on the acquisition of a major business equipment company. He invites '54 types to look him up in Newport Beach, Calif. . . . **Jerry Cohen** is Full Professor at Northwestern and Chairman of the Materials Science Department in the Engineering School as well as being active in research. Jerry is active in other areas too: shooting rapids in Utah with family (wife, boy 9, girl 12), visiting in New Hampshire and Philadelphia, traveling to Japan, and sailing in the Chicago area. . . . He reports that **Joe Kozol** is making money, literally, at the Franklin Mint and **Larry Leonard** is doing research at the Franklin Institute. Another invitation for '54 travelers; sailing with Jerry when in Chicago.

John Flender has been appointed Treasurer of the M.I.T. Development Foundation, Inc., a charitable organization designed to foster application of technological innovations to public needs. . . . **Geoffrey Hill** received a Ph.D. in meteorology from Penn State last March. . . . **Fred West** is continuing his research on double and multiple stars as a research associate at the Buffalo Museum of Sciences' Kellogg Observatory. He is also a part-time instructor for astronomy at State University of New York at Buffalo's Millard Fillmore College. Last summer, Fred obtained additional spectrograms of triple star ADS14893 at the David Dunlap Observatory and presented a paper on the triple star SD 27943 at the American Astronomical Society's meeting in Columbus, Ohio.

Charlie Smith reported in from the Penn Central that he and Pat are fine and the railroad is still running. He sent along an article from the *Philadelphia Inquirer* on Robert Moss, President of the Sierra Club. According to the article, Moss is a Class of '54 graduate from M.I.T. We can't find Mr. Moss listed in our Alumni Register. Is he an imposter, a secret member of our class—or what?—**David Howes**, Box 68, Carlisle, Mass., 10741; **Chuck Masison**, 76 Spellman Rd., Westwood, Mass. 02090

R. G. Dettmer, '55

55

Robert G. Dettmer has been appointed President and Chief Operating Officer of North American Van Lines, Inc. Previously he was President of the George J. Meyer Division of A.T.O., Inc., in Milwaukee, Wis. Prior to this he was President of the Scott Aviation Division of A.T.O. After graduation from M.I.T. he received an M.B.A. from Harvard Business School. The Dettmers have moved from Milwaukee to Fort Wayne and are in the process of building a new house. . . . **Charles W. Johnson** is the co-founder of a company called International Mathematical and Statistical Libraries, Inc. Formed in 1970, the firm produces a library of mathematical and statistical computer subroutines. They presently market three Fortran libraries for I.B.M., Univac, and C.D.C. computers. . . . **Paul C. Valentine** has been on a six-month sabbatical leave from his law firm. He is working for the Creative Initiative Foundation, an educational foundation in Palo

Alto that devises curricula and conducts seminars to educate man as to how he can become a more creative and responsive human being. . . . **Douglas East**, who is living in Paxton, Mass., has bought a Blaink. That's a two-place sailplane, and he and his boys spend all their spare time flying it from a field in Barre, Mass. He also feels that **Jim Eacker** deserves a lot of credit for obtaining new housing for A.T.O. . . . **Henry E. Theis** reports that a fourth son, Peter, was born last fall during plant inventory. Henry and his older boys have become great backpackers.

Attending the 1973 Alumni Day festivities were: **John Brown**, **Jim Eacker**, **Don Eckhardt**, **Ed Elizondo**, **Lloyd Gilson**, **Kealinge Keays**, **Dennis Shapiro**. Denny Shapiro has been elected to the executive committee of the M.I.T. Club of Boston.—**Allan C. Schell**, Secretary, 19 Wedgemere Ave., Winchester, Mass. 01890

56

Harry Foust has been promoted to Senior Application Engineer for the Trane Co., LaCrosse, Wisc., manufacturers of equipment for air conditioning, heating, ventilating and heat transfer. Harry will be responsible for special applications, preparing technical proposals, and selecting and designing products to fulfill system requirements. . . . **Hans Hoeflein**, who is Director of Operations of the pump and condenser group of his company for Europe, Africa, and the Middle East is in Belgium. Also there is **Marcel Huberland**, General Manager for Metallurgie et Mecanique Nucleaires, S.A., a Belgian company making nuclear fuel. . . . **Merlin Lickhalter**, who is on the National Board of Alumni Clubs, is Executive Vice President of the Drake Partnership, Architects, Inc., in St. Louis. He is Chairman of the Board of its affiliate, Health Systems Management, Inc. Merle is also a guest lecturer at Washington University, School of Medicine, conducting a graduate seminar on Health Care Facilities Planning. . . . **Bob McGillicuddy** was elected Vice President, Architectural Engineering of Anderson-Nichols and Co., Inc. in Boston last April.

William Oakes is in the newly created post of Vice President in Charge of Marine Systems for Marine Management Systems, Inc. This company designs and implements computer systems for the international marine industry. Bill, wife and their four children live in Fairfield, Conn. . . . Dr. **Dave Quigley** was certified in 1972 by the American Board of Orthopedic Surgery. He, Eileen and their five children live in the Providence area. . . . **Richard Quinn** has been appointed Director, Finance and Technical Services, R.C.A. Laboratories, Princeton, N.J. Dick is in charge of Engineering Services, Model Shop, Graphic Services, and Finance Activities. . . . **Jack Rosenfeld** announces the birth of a daughter, Helen, in April, 1973. Jack has been appointed Editor of the Proceedings of International Federation for Information Processing Congress, 1974, to be held in Stockholm. . . . **John Seeger** is in his second year as a doctoral student at Harvard Business School. . . . **Dick Skavdahl** writes from California that he is Manager of the power plant project and Program Manager of General Electric's Liquid Metal Fast Breeder Reactor Demonstration Plant.—Co-secretaries: **Bruce B. Bredehoft**, 3 Knollwood Dr., Dover, Mass. 02030; Mrs. **Lloyd Gilson**, 35 Partridge Rd., Lexington, Mass. 02173

57

Bob Tuffias dropped us a line that he's married, has two children and is member of the Senior Technical Staff, Litton Systems Guidance and Control Division. Bob has a Ph.D. from Stanford. . . . **Morton Rosenstein** has joined the faculty of the Woodstock Country School as Director of Development and Operations. Prior to coming to the Country School, Morton was the Federal Funds Administrator for the town of Needham, Mass. Prior to that he worked with Norton, Ionics and AVCO. The Woodstock Country School, a coeducational boarding school of over a hundred students, was founded in 1945. The school moved to its present 300-acre site, formerly Upwey Farms in South Woodstock, Vt., in 1955. With the institution of the Woodstock Plan in 1966, the Country School became the first private secondary school in the United States to operate on a year-round, four-term basis. . . . **Ed Roberts** co-authors a very interesting paper entitled Industrial Liaison Program—"Internal Entrepreneurship: Strategy for Growth." It was published in *The Business Quarterly*, Spring 1972 issue and is probably available as a reprint from the Sloan School of Management. I can strongly recommend it for reading. . . . **Mal Singerman** is currently the owner of a FANNING personnel agency franchise in Allentown, Pa. He adds in his note: "The change from working with computers to working with people is most enjoyable." . . . **Tom Tompson** has been elected president of the M.I.T. Club in Boston. . . . **Guy Carbone** is working on his JD degree from the evening division of Suffolk University Law School. Since 1966, he has been Chief of Engineering and Construction of the Government Center Commission, Commonwealth of Massachusetts, totally responsible to the Commission for coordinating and supervising all aspects of design and construction of the State Buildings in the Government Center of Boston, including Hurley Employment Security Building, Lindemann Mental Health Center, Garage and Plaza, and Mc Building and Garage, $70 million to date. A former member of the engineering faculty at Tufts University and the Harvard Graduate School of Design, Mr. Carbone, for the past nine years, has been a member of the Watertown School Committee and is also Chairman of the Watertown Permanent School Building Committee.

Finally here are some old items that I found in my files. **Chuck Murray** has been elected a Fellow in the American College of Physicians. Chuck is with the Department of Medicine of the St. Louis Park Medical Center. He and his wife Hilda have three children. . . . And a note from **Mike Brenner**: "After a three-year stint as an Associate Professor of Management at the Graduate School of Business Administration, I am starting as a venture capital consultant. I am joining the firm of Channing, Weinberg and Co., of which one founder is Barry Weinberg M.I.T. 1959. The company does assessments of new, small businesses in fields of high technology for investment bankers and individual, private investors. If anyone has a venture, give me a call (212-425-7444)."—**Fred L. Morefield**, Secretary, c/o Mobil Oil Caribe Inc., P. O. Box X, Caparra Heights Station, Puerto Rico 00922

59

I apologize for missing last month's deadline but I was recuperating from a combination of minor knee surgery and lack of news. Not fully recovered from either, this month's column is a bit lean!

Lynn Sykes was promoted to Full Professor of Geology at Columbia University last July. He is also Head of the Seismology Group, Lamont-Doherty Geological Observatory of Columbia University, Palisades, N.Y. . . . **George Connor**, now a Major, was graduated from the Army Command and General Staff College this past June and will be Depot Commander on Johnston Island in the Pacific for the coming year. Major **Ken** and Lillian **Kawano** are proud to announce the birth of a son, their first child, Kreiton Isamo, this past August 2. Yours truly is the nominal Godfather for the baby who was introduced to friends and family alike at a scrumptuous Hawaiian Luau held on the grounds of the Watertown Arsenal where Ken is stationed. . . . **Paul Cooper** obtained his Ph.D. in Engineering at Case Western Reserve last August (1972).

George Haymaker is presently in Fort Wayne, Ind., as President of R.E.A. Magnet Wire Co., a subsidiary of Alcoa. He has three children and a foster daughter. . . . **Phil Beach** is moving to Brazil (new address: c/o ALBA S.A. CAIXA Postal 438, Sao Paulo, Brazil) to be at the forefront of Borden's food operations there. "Hard to leave Venezuela but Brazil offers great challenge!" . . . **Pete Gottlieb** is currently Director of the Environmental Science Master's Degree Program at West Coast University (L.A.). . . . **Dave Moffett** received his Ph.D. from the University of Rochester in 1970 in high energy physics. Since that time he has been working in the High Energy Facilities Division of the Argonne National Laboratory. . . . **Ken Kellerman** who is with the National Radio Astronomy Observatory was recently honored by the National Academy of Sciences with the Benjamin Apthorp Gould Prize "for distinguished work in astronomical research."

New officers and directors of the M.I.T. club of Boston 1973-74 include Peter Vangel on the Board of Directors and **Neil Harper** on the Executive Committee. . . . At the Annual M.I.T. Awards Convocation this past June, **Dan Wang**, Associate Professor of Biochemical Engineering was presented one of the Graduate Student Council Awards for Outstanding

Graduate Teaching.

To those of you who see the names in this monthly column and can't place the faces, have I got a deal for you! ! The Technique has yearbooks from our year (1959) at a bargain price of $5.00 each. These can be obtained by writing Susan Burk, M.I.T. Branch, P.O. Box 5, Cambridge, Mass. 02139.

I have just received preliminary information from our reunion chairman, Lloyd Howells, that the site for our 15th reunion next June will be the beautiful Sheraton Regal Inn in Hyannis during the weekend of May 31, June 1-2, 1974. You will be hearing more about this not-to-be missed event both in this column and directly from the reunion committee.

Well, that's about all for now. Keep those cards and letters and envelop flaps coming.—**Art Collias**, Secretary, 61 Highland Rd., Brookline, Mass. 02146

61

Over the summer I got this sad letter from **Roger Hinricks** which he has permitted me to quote. "I am writing to inform you of the death of a member of the Class of 1961: **William Morse Shaw**. Bill died this last October (1972) of cancer in Berkeley, Calif., at age 33. He had been undergoing diagnostic x-ray treatments for several months but his rapid deterioration and death came as a surprise to everyone. Bill was a very good friend of mine for many years, starting at M.I.T., and I thought other of his friends would want to know of his passing.

"At the time of his death, Bill was a research associate in the Department of Electrical Engineering at the University of California at Berkeley. After earning his Ph.D. in theoretical solid state physics from the University of Washington in 1968, Bill went to work with the Lawrence Livermore Lab., in Calif., where he remained for three years. His work covered many areas in physics, including magnetic behavior of solids at low temperatures, astrophysics, and chemical physics.

"For the record, Bill was one of the warmest, most intelligent people I have known. He was thinking in a creative way much of his time, but was also a good listener and empathized with others' situations quite well. Besides his reading in many areas, Bill had interests in hiking and photography and was quite involved with a local Christian church. He remained a bachelor. Many of us will really miss this big man's presence."

I have not been getting very much news from you people over the last couple of months. Since a lot of my raw material comes along with contributions to the M.I.T. Alumni Fund it is no surprise that our Class seems to have the lowest participation in the Fund (cause or effect?) In any event some notes have trickled in recently. A couple of our classmates have received awards in the last couple of months. **Dick Naylor**, who is Assistant Professor of Geology at M.I.T., got a Baker award for "outstanding undergraduate teaching;" an award presented by the students. I gather that it is considered to be quite an honor and a little cash comes along with it too. . . . Down at Brown University **John Savage**, Associate Professor of Engineering, has two: "I have received a Guggenheim Fellowship and a Fulbright-Hays Award to support my Sabbatical leave from Brown during 73-74. I will do research in theoretical computer science in the Mathematics Department, Technical University—Eindhoven, the Netherlands." John has been at Brown since 1967 and will be studying how to best make use of storage capacity and time to increase computer efficiency.

Bernard Lech writes that his family is growing, the balance going over toward the feminine. He says, "Add to a wife (Libby) and a daughter (Gretchen, 3), a healthy new daughter (Heather Elizabeth, born in Boston, May 19, 1973.) I am currently working for Bio-dynamics Inc., of Cambridge, Mass., as a Project Director—Management Systems Analysis. We have been living in Stowe, Mass., since September, 1971 and enjoy all but the commute." . . . **Charles Suter** is still a student! He is in medical school and says that he loves it. He is at the University of Virginia in Charlottesville. He finds "C'ville" is not too exciting but is "easy-living." It's nice country, he says, and says that passers-by can find him through the dean's office. Charlie goes on to write that "Medicine is one hell of a switch from Course VI. I amuse myself by going through old texts now and then." . . . An interesting note from **Randall Garriott** who wrote, "I got a B.S. in physics at the University of Louisville, Ky., (1962) after leaving the Institute in '59. My wife, Joy, is/was a teacher (B.S., Education, Indiana State, 1962). My son Greg, born in 1965, and my daughter Gayle, in 1968, have sidelined Joy's teaching. I presently am designing a data system to speed provision of special communication services." . . . **Joe Harrington** is returning to Boston (lock up your wives and daughters) from Illinois to work for New England Electric. He will still be working in the nuclear power business and they really need him around here.

George Harrison is out on the coast in Seattle peddling municipal bonds for Merrill, Lynch. He and wife Karen will be announcing the birth of a child any day now. . . . Also on the west coast is Captain **Bill Abbot** where he is Naval Rep at Lockheed in Sunnyvale, Calif. My records show that he has been out there since, at least, 1966. . . . Here in the East, in Asheville, N.C., lives **Peter Robb** who is Director of Planning and Engineering at Olin's Fine Paper and Film group. Pete has three children; Lisa, 11; Peter, 9; and Christopher 6. . . . **Richard Miller** also has three children: Eric Solander who is 7 months; Julie, 8 and Sara, 6. Dick is still a technical director for the New Castle, Del., Polypropylene Plant of Amaco Chemicals Corp.

Finally a note from **Bruce Bardes**: "I probably reported it earlier, but I'm now Chief Metallurgist and Research Engineer for a small firm which makes pneumatic cylinders. This work and my prior professoring at two major colleges has absolutely convinced me that engineering education *must* have greater emphasis on solving real problems. Although I'm not now teaching I'm still working hard to preach my beliefs. I'll write more if you'd find it useful for *Technology Review*." Well, Bruce, I think that a lot of this column's readers would be interested in the opinions of a working engineer on the state of engineering education. I'll fight to get your opinions and those of other interested people into the *Review*. (What do you all think about pass-fail?)—**Andy Braun**, Secretary, 464 Heath St., Chestnut Hill, Mass. 02167

62

Earl R. Ruiter will be traveling to Bruges, Belgium in June to present a paper on equilibrium in transportation networks at the International Conference on Transportation Research. . . . **Thomas Wiener**'s wife, Louise informs us that he is at sea and is the C.O. of the nuclear-powered submarine U.S.S. *Jack*. . . . **Loren C. Skinner, 2nd** has recently joined the Data General Corporation's Semiconductor Research and Development Division in Sunnyvale as a member of the division's founding group. . . . **Warren M. Zapol**, M.D. has been appointed Professor of Anesthesia, Harvard Medical School at Mass. General Hospital and also received N.I.H., Research Career Development Award for five years of study on the clinical use of artificial lungs in acute respiratory failure. He also has a son David, born May, 1972. . . . **Ernest E. Kirwan** is now an associate partner in the architecture-engineering firm of Fenton and Keyes Association (Providence and Waltham). He is also a member of the Executive Committee Neighborhood Ten Association in Cambridge and Vice President, Rhode Island School of Design Alumni Association. . . . **George Meyer** passed his internal medicine board exams in June, 1972, and is now an internist at Tachikawa U.S.A.F. Hospital outside Tokyo, Japan. . . . **Edward A. Feustel** is currently Associate Professor of Electrical Engineering and Computer Science at Rice University. He married Delycia E. Howard in December, 1971, a registered nurse. They bought a house and spend their spare time fixing it up. Their other activities include ham radio (W5THF), gardening, and church activities. They also would enjoy hearing from old friends in the Class of 1962. . . . **Kenneth Y. Wang** is moving his family back to Hong Kong after an absence of 13 years to take on a new business assignment. He lets us know that anyone visiting Hong Kong will be welcome and to ring him up (K-646009). He will be happy to assist you in any manner he can.—**Gerald L. Katell**, Secretary, 7 Silverbit Lane, Rolling Hills Estates, Calif.

63

October 1973. Indian summer seems like a strange time to be writing for a December *Technology Review*, but here I am. I have a good supply of current news (June through August '73) and this column is devoted mainly to that news.

Our class reunion in June was a week

after the M.I.T. Alumni Day and the set of those who attended the functions at the Institute had no intersection with the set of those who spent the weekend on Martha's Vineyard. The Class of '63 was represented at Alumni Day by **Richard Durst**, **Stephen Gould**, **Robert Maskrey**, **Harold Payson**, **David Shawaker**, and **Norman Weeks**.

Looking back into my file of old news I find a note from **Harold Payson** dated September, 1972. This information may be a bit late, but I have much, much older data on some of you—going all the way back to 1971. In fact, I have quite a dossier on some classmates—several years worth of notes in some cases. In 1972, Harold was coordinator of the Natural Sciences Division at Roger Williams College in Bristol, Rhode Island. He was devoting special effort toward establishing marine sciences courses with emphasis on the problems of Narragansett Bay. The program was in need of a boat and a marine lab. Let me know whether you got the equipment you needed—maybe someone in the Class can help out.

News and notes from the Reunion: **Dan Ross** is practicing law in Philadelphia—particularly income tax law. Wife Faye is home, taking care of two-year-old Kevin. In their spare time both Rosses are taking care of their 50-year-old stone house in Philadelphia. Dan notes that he periodically runs into **Rich Weiner**. Lo and behold—consulting the old news file we find a note from Rich Weiner (written in December 1971.) Rich is Chairman of the Pennsylvania Securities Commission, and he became Chairman of the Young Lawyers Section of the Philadelphia Bar Association in June, 1972. Rich also wrote that a son, Matthew Aaron was added to his family in August, 1970. If this information had taken much longer to get into print Matthew might have been old enough to read it himself. . . . Donna and **John Brach** are living in Fairfax, Va., with their two children, Brian, 3½ and Suzanne, 1. John is doing resident engineer work with Sverdrup and Parcel on Washington's Metro subway system and Donna is teaching prepared childbirth classes. . . . **D. Allen Meyer** is also living in the Washington, D.C. area and is working for Uncle Sam.

Tony Doepken is Engineering Manager at High Voltage Power Corp., in Westboro, Mass. He and his wife Betsy have two children, ages 4 and 2, and enjoy the lifestyle of Westboro—a typical small New England town. Tony heard from several other classmates, including all of the following: Lois and **John Flaherty** are living in Baltimore and working at Johns Hopkins Hospital. John is completing a residency in cardiology while Lois is working in child psychiatry. . . . **Mike Finson** is working with lasers at Avco Everett Research Laboratory. Two recent news clips from Avco inform us that Dr. Finson has been named Chairman of the Aerophysics Research Committee at the Lab.

More news from Tony's note: Another classmate, **Paul Berger**, is also doing laser work, at United Aircraft. . . . **Jim Graham** is still enjoying bachelorhood and working at Emerson Electric in St. Louis as a senior electrical engineer. . . . Margie and **Saul Cherkofsky** are in Wilmington, Delaware. Saul is with Dupont's Research Division. . . . **Bob Turnbull** is Associate Professor of Electrical Engineering at the University of Illinois at Urbana.

Gene Sprouse is Assistant Professor of Physics at the State Univ. of N.Y. at Stony Brook. Gene is in Japan this year as a visiting professor at the University of Tokyo, on a Sloan Fellowship. He wrote in May '73 that he was studying Japanese at the New School in New York City. Drop me a card, Gene, and let me know how you're doing. Send a colorful stamp—my daughter Amy collects stamps and she likes the Japanese issues. Regards from my family to yours.

To be continued next month—I've used up my space allotment for the December issue.—**Mike Bertin**, Secretary, 18022 Gillman St., Irvine, Calif. 92664

64

An autonomous Class Hero who apparently works for Arthur D. Little, Inc., in Cambridge (autonomous because he omitted what I surmise was to be the second page of his letter) reports that he attended the M.I.T. Alumni Officers Conference this September and saw **Robert St. Aubin** and **David Morrison**. Robert is a corporate lawyer working for F.M.C. Corporation in Philadelphia, while David is the owner and operator of a sizable tire business in West Sand Lake, N.Y. . . . **Mark Alpert** has been promoted to Associate Professor of Marketing Administration at the University of Texas. . . . **William Beck** has been named Marketing Manager for F.M.C. Corporation's phosphorus chemicals group. . . . **Thomas Cerny** has been elected assistant comptroller of Arcata National Corporation in Menlo Park, Calif. . . . **Juan Crawford** is with the sensor sciences group at Industrial Nucleonics in Columbus, Ohio. He says he is holding the line at four children. . . . **Donald Faber** is an assistant professor at the College of Medicine in Cincinnati. Don, his wife Jo, and their two daughters have recently returned from two years in Europe where he was a research associate in two neurophysiology laboratories. . . . **Patrick Gage** and his wife Nancy are the proud parents of a son Danen John. Pat is on the staff of the Roche Institute of Molecular Biology in Nutley, N.J. . . . **Jim Giffin** has been promoted to vice president of the First National Bank of Chicago. He is in charge of aerospace and airlines financing, and as such attended the Paris Air Show. . . . **Margaret MacVicar** has been honored by being named the Class of 1922 Assistant Professor in M.I.T.'s Physics Department. . . . **Jeffrey Michel** has been living in Lahr, West Germany, not far from Strasburg. He was recently made group leader for audio electronics development at Geraetewerk Lahr, which is prominent for studio equipment sold under the name E.M.T. . . . **Herbert Norton** became the father of his first child Heather Alice this past March. . . . **Peter Politzer** was recently appointed Assistant Professor in the Department of Nuclear Engineering at M.I.T. . . . **Ronald Randall** has just joined Maritime Fruit Carriers Co., Ltd., an Israeli-based shipping and ship financing firm. Ron is responsible for American financing activities. . . . **Don Shapero** is going on a month long trip to Moscow as part of an exchange program between the Academies of Science of the U.S. and Russia. He will present a paper on magnetism and will visit laboratories. . . . **D. J. Silversmith** and his wife Linda now have a one-year-old son Jolyon Andrew. He reports that **George Irwin** is close to his Ph.D. at Berkeley, that **Phil Dangel** is with Kennecott in Lexington, Mass., and that **Bruce Chrisman** is doing computer work for Argonne in Chicago. . . . **Glenn Stith** is now a senior geologist with Amoco, which Glenn notes is a strange position for a math major. Glenn and his wife Suzan have two children. . . . **Michael Stulbarg** has completed his internal medicine residency and is now a Pulmonary Fellow at the University of California in San Diego.

Leonard Theran and his wife Susan have a one year old daughter Sally Ann. . . . **J. A. Timoshenko** has a son Stephen Gregory almost one year old, and finds himself well-challenged at his work with General Electric in high energy generators. . . . **Thomas Vicary** has been advanced to Manager of Marketing of the Erie City Energy Division of Zurn Industries, Inc. Tom, his wife Cherly, and their three children live in Erie, Pa. . . . As a final note, I might mention that Yours Truly has been elected for a two year term to the Board of Directors of the Memphis and Shelby County Bar Association, and will be President of the Young Lawyers of Memphis in 1974.

That's the news for now. Happy New Year to everyone.—**Ron Gilman**, 5209 Peg Lane, Memphis, Tenn. 38117

65

Greg Schaffer is this month's good guy, as he actually wrote a real letter. After graduating from Tech, Greg went to Berkeley for a master's in Electrical Engineering. He spent two and one-half years with N.A.S.A. then got a master's in Computer Science from the University of Arizona. Greg then spent a year and a half at Purr-Brown Research Corp., and is now Development Manager for premium digital voltmeters at Dana Laboratories in Irvine, Calif. Greg married the former Susan Thackeray in December, 1968. He is still interested and active in mountaineering and has recently taken up piano and organ. Greg is interested in finding **Dick Sherman**.—says he was last known at Cal Tech. Can anyone help?

Martin Thomas reports the birth of a second child, Sally. Martin is still Marketing Information Manager for Scott Paper Co. . . . Sharon and **Dave Rubin** have a new son, Joshua, born last June 19. . . . Brenda and **Chris Miller** had a son, Jeffery, last June. Chris is on the technical staff of the Hughes Tucson Engineering Laboratory. He is also active in the local Toastmasters and the Hughes Tucson Management Club.

Rosemarie Wipfelder Kumpe married David Kumpe in May 1971. Since July

1971 the Kumpes have lived in Maryland. Rosemarie is Assistant Professor of Radiology at the University of Maryland School of Dentistry and David is at the National Institute of Health in Bethesda. The Kumpes have a son, Carl Christian, born in May 1972. Rosemarie received her S.M. in Radiological Health from Harvard in 1970. . . . **Jim McMillan** will begin a year as Chief Resident (I don't know where) on July 1. After that he plans to enter private practice and may work on an Indian reservation. . . . **Jim Steele** has been named product line manager at Digilab, Inc. . . . **Mike Lang** is currently Chief of Anesthesia at Kirk Army Hospital at Aberdeen Proving Ground, Maryland. Mike and Dorrie have a son, Chris and expect another youngster soon. Mike hopes to return to Mass General Hospital next year. . . . **Tom Maugh** is coauthor of a new book *Energy and the Future* published by the American Association for the Advancement of Science. . . . **Stan Pliska** is Assistant Professor of Industrial Engineering at Northwestern, and has received a $19,600 grant for research in queuing networks from the National Science Foundation. . . . and **Dick Sidell** is now a DuPont Assistant Professor at M.I.T.

And that's the short column for December. Why not send a Class Notes letter for Christmas to **Steve Lipner**, Secretary, 3703 Stearns Hill Rd., Waltham, Mass. 02154

66

It has been extremely interesting over the past two years to hear from many members of the Class on a relatively regular basis. During that time I have received a number of unusual letters but continue to be amazed by the number of people still in school. After more than ten years in "higher" education it would seem that it is time to get down to work! My congratulations go to those who are still at it and condolences to those who have recently graduated. . . . From **John Stampfel**, "Having recently completed my Ph.D. in solid state physics at Carnegie-Mellon I am in a somewhat unrelated field at Bell Labs—working on a computer voice response system." He and his wife Priscilla have two children.

Dave Enfield received his Ph.D. last year from Boston University in Physiology. He is now involved in studies on the chemistry of the blood clotting system at the University of Washington. **Joseph Sullivan** received his M.S.I.A. from Carnegie-Mellon G.S.I.A. and has taken a management position with MEDRAD; Inc., a medical instrument and electronics company in Pittsburgh. He will be in charge of financial planning and production. **Mark Friedman** writes that "in 1972, after six years in scenic Newark, N.J. I got married, got my Ph.D. and got out! We are currently spending a marvelous year in Edinburgh, Scotland where I am researching the visual systems of birds and babies." . . . **George Randall** has just completed his master's in Chemical Engineering at the 'tute and is now a Sr. Staff Engineer for Distrigas Corp., in Boston. . . . **Bob Silver** (my lab partner in several abortive Course II experiments) finished his Ph.D. in Mechanical Engineering at Syracuse last year. He is now working at DuPont in Richmond, Va. I have promised Bob not to let DuPont read our results.

Marvin Sirbu finished his Sc.D. in Course VI and he is now working at M.I.T.'s Center for Policy Alternatives. . . . **Jim Veazey** graduated in 1971 from Harvard Med-School and is in his second year of residency in internal medicine at the Dartmouth affiliated hospitals. He was married in June, 1972 and he and his wife just returned from a belated honeymoon in England and W. Germany. . . . **James Miller** completed his Ph.D. in applied math at the University of Maryland and went to Colorado for a year of Postdoctoral work at the National Center for Atmospheric Research in Boulder. . . . **Ronald Ward** reports that "after a frantic rush to finish my Ph.D. thesis in geophysics at Tech, Carolyn and I spent a leisurely six weeks in northern Europe. Upon our return, we left M.I.T. and Boston for the Southwest where I am a Res. Scientist for AMOCO Production Co., Research Laboratory in Tulsa. . . . **Paul Kebabian** received his Ph.D. in Course VI last June and is doing research at the Institute this year. **R. D. Camerini-Otero** graduated from the M.D.-Ph.D. program at the N.Y.U. School of Medicine. He is interning at Bellevue Hospital currently. Dr. **Robert Munger** has started his medical residency at the University of Vermont. . . . Last, but certainly not least, **William Marlow** expected to receive his Ph.D. this past summer from the University of Texas at Austin.

In other news . . . **Carson Eoyang** is the father of a baby girl born this past Chinese New Years, 3 February. . . . **Raymond Petit** has resigned his commission in the navy and has moved to Oak Harbor to start his own company, Petit Logic Systems. The company designs and manufactures digital communications equipment. **Charles Davis** has been appointed an Associate Partner in the architectural firm of Skidmore, Owings and Merrill and, in addition, is the Director of Data Processing for the firm. He will be located in the firm's Chicago Office.

William Nelson has left Lehigh's Physics Department and is now at the University of Delaware studying the properties of photovoltaic solar cells. Since October 1972, **Leonard Russo** has been working at N.R.L. in Washington, D.C. . . . **Eugene Soltero** has been named General Manager of Moore-McCormack Energy, Inc. . . . **John E. Gordon** has recently been named the New England Regional Manager of Bausch and Lomb's Ophthalmic Division. . . . **Joe Shaffery** has left sunny California to become a Staff Assistant for the Allen Group, Inc., of Melville, Long Island.

Ken Baxter has been working for I.B.M. since graduation. After spending five years in Oswego, he moved to Gaithersburg, Md., and then to Manassas, Va. He is presently a Staff Engineer in I.B.M.'s Shipboard Systems Group. . . . **Thomas Rice** has finished two years at U.S.P.H.S. Indian Hospital in Wagner, S.D. This past summer he started residency at Stanford University Medical Center in Palo Alto. . . . **Harry Moser** writes "Barbara, Robert and I have been living in beautiful Hensdale, Ill., for two years. I am Director of Research and Marketing for DISMATIC, Inc." . . . **Bert Forbes** and his wife Candee have been living in Geneva for 18 months. He worked on the development of Hewlett-Packards new HP3000 computer and is now supporting it in Europe. . . . Susan and **Gene Sherman** have moved to Pittsburgh where he will be a Cardiology Fellow and Susan will be a medicine intern.

One final note—the Class did particularly well in this year's Alumni Fund Drive. Although many people contributed to the effort, Class Agent **Ken Browning** deserves a great deal of credit for making our percentage participation the highest of any class graduated in the past 30 years. That's it for this month.—**Tom Jones**, Apartment 6, 59 Commercial Wharf, Boston, Mass. 02110

67

Ralph Sawyer forwarded the following tragic news story which appeared in the July, 1973 Bulletin of the Loomis Institute, Windsor, Connecticut: "**Sam Guilbeau** is lost. He was in Viet Nam and when he returned he went to Caltech in California and finished M.I.T. with his master's in physics. After that he received his master's in geology. He then took a trip to Canada in a canoe—800 miles alone. He rowed one day and rested and studied the next. In the middle of July he hiked from the Yukon to Butter Isles and was supposed to fly back to California where he had a job waiting. He never made it. An air-search party in August thought they saw him in a yellow air-tight suit and green tent, but it was someone else. Sam had left food in three places—one was never touched. Planes searched for him until it got too cold. He was supposed to be in California by last September 14. No later news."

Ralph Sawyer and Sam Guilbeau were classmates at the Loomis School. Ralph now works for three different companies in Taipei, Taiwan: he is general manager and half partner in C.S. Industries, a company which operates two electronics factories; he is managing engineer for Taisports, a large tennis manufacturer; and he is general manager of Sports World, an export house which also operates two factories. Ralph is also finishing his dissertation on Chinese Psychology and continuing research in traditional Chinese medicine. He received his M.A. in Chinese studies from Harvard in 1970 and should get his Ph.D. next spring. Before going to Taiwan Ralph spent one year at Boston University as a lecturer in the Department of Religion. Although Ralph is entertaining thoughts of joining the Department of History at University of Maryland, he and his wife are reluctant to leave their pleasant life in Taiwan. Anyone going to Taiwan should look them up. . . . After eight years in Cambridge **Yu-Po Chan** is with Peat, Marwick, Mitchell and Co., in Washington, D.C. He received his Ph.D. from M.I.T. in 1972. . . . **Mike Zuteck** completed his master's in Physics at Illinois

in June after working four years with the Apollo program. . . . **David Saunders** finished his Ph.D. in Biology at John Hopkins in 1972 and is now at Boston Biomedical Research Institute.

In September, 1972, **Alan Perelson** completed his Ph.D. in Biophysics at Berkeley, and in October his wife Janet presented him with a daughter, Elissa Danielle. The Perelsons have moved to Minneapolis where Al is doing research under an N.I.H. grant. . . . **Jerry Yochelson** is keeping busy at UNI-TOTE in Hunt Valley, Md. His son Dan Samuel arrived April 2. . . . **John Jamieson**, father of two girls, is still with N.A.S.A. in Florida. He owns Jay Jay Marine Supply, a discount boat supply company. . . . **Carl Doughty** is a civil engineer and computer specialist with the Philadelphia District of Corps of Engineers. . . . **Tom Larsen** is working for the Badger Co., which is headquartered in Cambridge, Ma. About a year ago he and Audi were transferred to The Hague for a two-year stay. Before leaving for Europe they took a nine-week camping trip across the United States. With a van and two trail bikes they visited the West Coast from British Columbia to California. They climaxed their trip with a nine-day raft trip down the Colorado through the Grand Canyon. . . . **Bill Murray** writes: "After abandoning the melting iceberg of physics, I now find myself, as ex-physics majors are wont to do, pursuing that intellectual will-of-the-wisp, the M.B.A., at scenic University of Michigan."

John Marshall is still trying to get his Ph.D. in Organic Chemistry from Rensselaer Polytechnic Institute, having been interrupted for two years by Uncle Sam and distracted by his November, 1969, marriage to the former Myra Lyman. . . . **Car Kalinowski** has found a successful sideline in Shaklee, a direct seller of organic cleaners, cosmetics and food supplements. . . . **Ed Jakush** writes: "I've moved to San Francisco and bought a 70-year-old Victorian which I am remodeling. I play rugby for the San Francisco Rugby Club and cover the West for Rohm & Haas. Luckily, most of my current marketing work is in the wine industry, and I crush grapes from August to October and 'evaluate' the results during the rest of the year". . . . **Stuart Schaffner** has married Ann Carrad, a librarian at the Boston Public Library. They plan to live in Melrose. . . . Marsha and **Gerry Starkeson** have their first child, Ellen Rebecca, born January 18, 1973. Gerry is a project engineer at Nashua Corp., and Marsha is a computer software consultant. . . . Edie and **Chuck Hottinger** have their second cute daughter, Aimee Elizabeth, born August 15, 1973. . . . Although Class Hobo **Jeff Schoenwald** claims to be writing his doctoral thesis at University of Pennsylvania, it appears that he spends most of his time traveling. His latest trips have been to Freeport, Grand Bahamas, and Miami. He should be out of school by the time this appears in print.—**Jim Swanson**, Secretary, 11567 Circle Way, Dublin, Calif. 94566

72

A number of short items this month. From somewhere in the wilderness beyond the Berkshires, **James Mosora** writes that, as a Physics T.A. at Purdue, he is "helping develop a self-paced physics course for life science majors based on 8.01X, drinking beer, and watching T.V." . . . Elsewhere in academia, **Paul Lentrichia** is at medical school in the Bronx. . . . **Paul Rutter** and **James Milner** are grad students in computer science at the University of Illinois. . . . **Sheldon Jay Price** is studying physics at Brandeis. . . . **Elliot Riegelhaupt** is at Albert Einstein College of Medicine. . . . **Eugene Kroch** is entering grad school in economics at Harvard after a year as an R.A. . . . **Larry Klein** is in his second year at Johns Hopkins. He spent the summer working in a psychiatric ward and doing research aimed at improving the first year curriculum at the medical school. . . . **Jane Matrisciano** writes that "New Haven and Yale English haven't managed to be a satisfying replacement for Boston and M.I.T., even after a year." . . . Closer to home, **John Scalea** is starting on an interdepartmental doctoral program in air transportation at the Institute.

Among those of us who have entered the real world, I bumped into yet another classmate at G.E. in Lynn recently (or more precisely at the excellent sub shop down the street). **Robert A. Walter** is working in the Medium Steam Turbine group after picking up his master's in Course II. . . . **Simon Wieczner** is working at Imlac Corp., a small display minicomputer firm, as a technical writer. . . . **Rick "Nord" Brylczyk** writes that he is "living in God's Country and working on the aerodynamics staff for the Boeing 727."

In other news, **Don Levinstone** has returned from his travels to India, Pakistan, Nepal and other points east and has settled down to the mundane life of trying to get a master's at M.I.T. . . . **Douglas Mahone** writes, "I'm exploring the practical end of the building industry as a self-employed builder/designer. I'm living and working on a small island in Maine, building what I design—two new houses and several renovations so far. Planning graduate work in architecture for 1974." . . . Finally, **Joe Kashi** sent "a note on life in the steam jungle along the Potomac. I'm continuing my summer job on the Joint Economic Committee of Congress; looks like I'll be working indefinitely on NATO and other defense/economic matters for Senator Proxmire. I have also started my first year at Georgetown Law School. Between a half-time job, full-time law school, and fixing up a suburban house, it's a hassle, though not much worse than trying to pass M.I.T. while working full-time on the *Tech* for lo these many years. I'm rooming with Dave Kaye '68, who is a practicing attorney, Dave's wife, and three others, two of whom are law students. Luckily, Dave used to be a physicist, so the dinner conversation isn't usually law-related. **Editor's Note** We would like to apologize for reporting **Don Coppersmith** '72 as deceased in the July/August Deceased list. Apparently we confused him with his father who passed away in December 1972.—**Dick Fletcher**, Secretary, 135 West St., Braintree, Mass. 02184

Conversation Pieces

Technically intriguing items from TRW, guaranteed to add luster to your conversation and amaze your friends.

Tornadoes, Rockets and Sonja Heine

So far, 1973 has been a banner year for tornadoes. By mid-year, more than 750 of these violent storms had swept down on the United States, killing 59 people and causing millions of dollars in property damage. Scientists expect the existing tornado record of 928 (set in 1967) to be easily shattered before the year is over.

Recently, tornado research has received help from an unexpected source — namely, studies made by TRW scientists of flow patterns in the propellant tanks in ICBM missiles. When you pump fuel out of a liquid rocket tank, much the same thing happens as when you pull the stopper out of your bathtub — a radial flow pattern develops (the particles move in spiral paths toward the center) and a vortex appears. To find out how swirling fluids behaved in propellant tanks, TRW scientists made some fundamental studies of the formation and behavior of vortexes. Further research has extended their analyses to the behavior of the large vortical patterns in the atmosphere we know as tornadoes, waterspouts, dust devils, and fire whirls.

A tornado begins with a thermal instability in the atmosphere, e.g., large mass of warm moist air under a layer of cold dry air. Under such conditions, violent updrafts may begin, around which the surrounding air begins to flow radially inward, in a swirling, spiral pattern. As particles get closer to the center of the flow pattern, their velocity increases. Some readers will recall the startling rotational speeds Sonja Heine achieved as she drew her extended arms closer to her body. Particles of air experience this same increase in rotational velocity as they get closer to the center of the system.

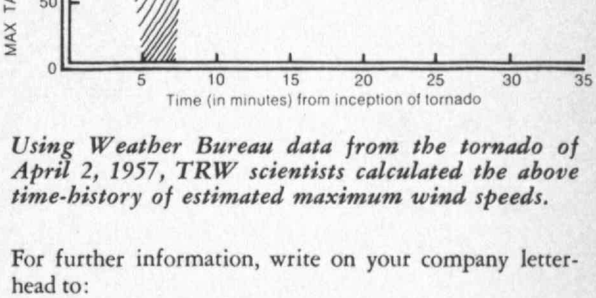
Ordinarily, turbulent diffusion opposes the swirling, and relaxes the disturbance — i.e., friction prevents Sonja from bringing her arms inward. However, in rare circumstances the radial inflow overwhelms turbulent diffusion, and a tornado develops. Actually, in a killer tornado much of the radial inflow is eventually confined to a layer near the ground, because at greater heights the increase of swirling ultimately creates a large centrifugal force that counteracts further radial inflow.

While dust and debris are being swept upward, the funnel of the tornado appears to descend. The latter occurs because the faster the air swirls, the more its temperature drops and the less moisture the air can contain. The resulting condensation of water vapor is seen as the funnel of the tornado, snaking down from the ominous cloud deck. Using these facts, TRW scientists have developed a formula which enables them to calculate the maximum velocity of winds in a tornado.*

TRW scientists have estimated the maximum wind speed in the funnel of a major tornado at around 225 m.p.h. Much of a tornado's destructiveness, however, stems not from the speed of the swirling wind, but from the radically low pressures inside the funnel. As a tornado engulfs a building, air trapped inside the building causes it to explode.

While much remains to be learned about large vortical storms, TRW's work with swirling liquid rocket propellants has lead to an important meteorological understanding of the behavior of destructive rotational storms.

**Maximum velocity, $V = (kgh)^{1/2}$, where h is the altitude of the cloud deck, k the fraction of the distance between cloud and ground the funnel cloud tip has descended, and g the acceleration of gravity.*



Using Weather Bureau data from the tornado of April 2, 1957, TRW scientists calculated the above time-history of estimated maximum wind speeds.